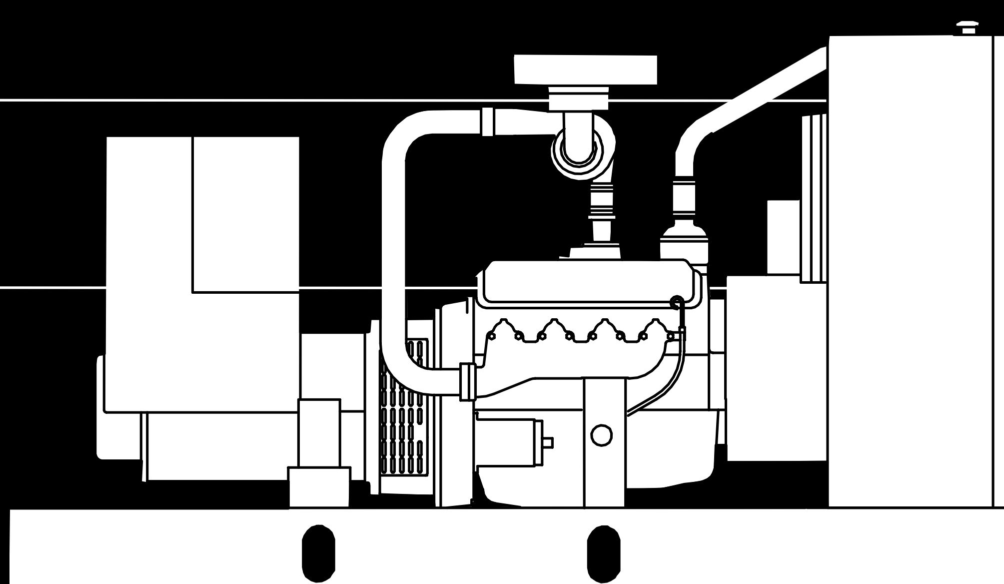
Caution: This document contains mixed page sizes (8.5 x 11 or 11 x 17), which may affect printing. Please adjust your printer settings according to the size of each page you wish to print.

Service Manual

ENA
ENB
ENC
ENAD
ENBA

GENERATOR SETS



Printed in U.S.A. 928-0500 3-92

Table of Contents

SECTION	TITLE	PAGE

Safety Precautions

Before operating the generator set, read the Operator's Manual and become familiar with it and the equipment. **Safe and efficient operation can be achieved only if the equipment is properly operated and maintained.** Many accidents are caused by failure to follow fundamental rules and precautions.

The following symbols, found throughout this manual, alert you to potentially dangerous conditions to the operator, service personnel, or the equipment.

DANGER ***This symbol warns of immediate hazards which will result in severe personal injury or death.***

WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

FUEL AND FUMES ARE FLAMMABLE

Fire, explosion, and personal injury or death can result from improper practices.

- DO NOT fill fuel tanks while engine is running, unless tanks are outside the engine compartment. Fuel contact with hot engine or exhaust is a potential fire hazard.
- DO NOT permit any flame, cigarette, pilot light, spark, arcing equipment, or other ignition source near the generator set or fuel tank.
- Fuel lines must be adequately secured and free of leaks. Fuel connection at the engine should be made with an approved flexible line. Do not use copper piping on flexible lines as copper will become brittle if continuously vibrated or repeatedly bent.
- Be sure all fuel supplies have a positive shutoff valve.
- Be sure battery area has been well-ventilated prior to servicing near it. Lead-acid batteries emit a highly explosive hydrogen gas that can be ignited by arcing, sparking, smoking, etc..

EXHAUST GASES ARE DEADLY

- Provide an adequate exhaust system to properly expel discharged gases away from enclosed or sheltered areas and areas where individuals are likely to congregate. Visually and audibly inspect the exhaust daily for leaks per the maintenance schedule. Ensure that exhaust manifolds are secured and not warped. Do not use exhaust gases to heat a compartment.
- Be sure the unit is well ventilated.
- Engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Keep your hands, clothing, and jewelry away from moving parts.
- Before starting work on the generator set, disconnect battery charger from its AC source, then disconnect starting batteries, negative (-) cable first. This will prevent accidental starting.
- Make sure that fasteners on the generator set are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- Do not wear loose clothing or jewelry in the vicinity of moving parts, or while working on electrical equipment. Loose clothing and jewelry can become caught in moving parts. Jewelry can short out electrical contacts and cause shock or burning.
- If adjustment must be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Remove electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surface to be damp when handling electrical equipment.
- Use extreme caution when working on electrical components. High voltages can cause injury or death. DO NOT tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag and lock open switches to avoid accidental closure.
- DO NOT CONNECT GENERATOR SET DIRECTLY TO ANY BUILDING ELECTRICAL SYSTEM. Hazardous voltages can flow from the generator set into the utility line. This creates a potential for electrocution or property damage. Connect only through an approved isolation switch or an approved paralleling device.

HIGH VOLTAGE GENERATOR SETS (1.9kV to 15kV)

- High voltage acts differently than low voltage. Special equipment and training is required to work on or around high voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Due to the nature of high voltage electrical equipment, induced voltage remains even after the equipment is disconnected from the power source. Plan the time for maintenance with authorized personnel so that the equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator or heat exchanger pressure cap while the engine is running. Allow the generator set to cool and bleed the system pressure first.
- Benzene and lead, found in some gasoline, have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking, draining or adding gasoline, take care not to ingest, breathe the fumes, or contact gasoline.
- Used engine oils have been identified by some state or federal agencies as causing cancer or reproductive toxicity. When checking or changing engine oil, take care not to ingest, breathe the fumes, or contact used oil.
- Provide appropriate fire extinguishers and install them in convenient locations. Consult the local fire department for the correct type of extinguisher to use. Do not use foam on electrical fires. Use extinguishers rated ABC by NFPA.
- Make sure that rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and engine damage which present a potential fire hazard.
- Keep the generator set and the surrounding area clean and free from obstructions. Remove any debris from the set and keep the floor clean and dry.
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.
- Substances in exhaust gases have been identified by some state or federal agencies as causing cancer or reproductive toxicity. Take care not to breath or ingest or come into contact with exhaust gases.

1. Introduction

ABOUT THIS MANUAL

This service manual is for the EN series gasoline- and gaseous-fuel generator sets. It includes engine and generator troubleshooting guides. Engine service instructions are in the applicable engine service manual. Operating and maintenance instructions are in the applicable Operator's Manual.

This manual does not have instructions for servicing printed circuit board assemblies. Always replace a faulty printed circuit board assembly. Attempts to repair a printed circuit board can lead to costly damage to the equipment.

This manual contains basic (generic) wiring diagrams and schematics that are included to help in troubleshooting. Service personnel must use the actual wiring diagram and schematic shipped with each unit. The wiring diagrams and schematics that are maintained with the unit should be updated when modifications are made to the unit.

Read ***Safety Precautions*** and carefully observe all instructions and precautions in this manual.

TEST EQUIPMENT

Most of the tests in this manual can be done with an AC-DC multimeter, frequency meter, Wheatstone bridge (0.001 ohm precision is necessary for measuring stator winding resistance) and load test panel.

HOW TO OBTAIN SERVICE

Always give the complete Model and Serial number of the generator set as shown on the nameplate when seeking additional service information or replacement parts. The nameplate is located on the side of the generator output box.

⚠WARNING ***Incorrect service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service. Read and follow Safety Precautions, on pages ii and iii.***

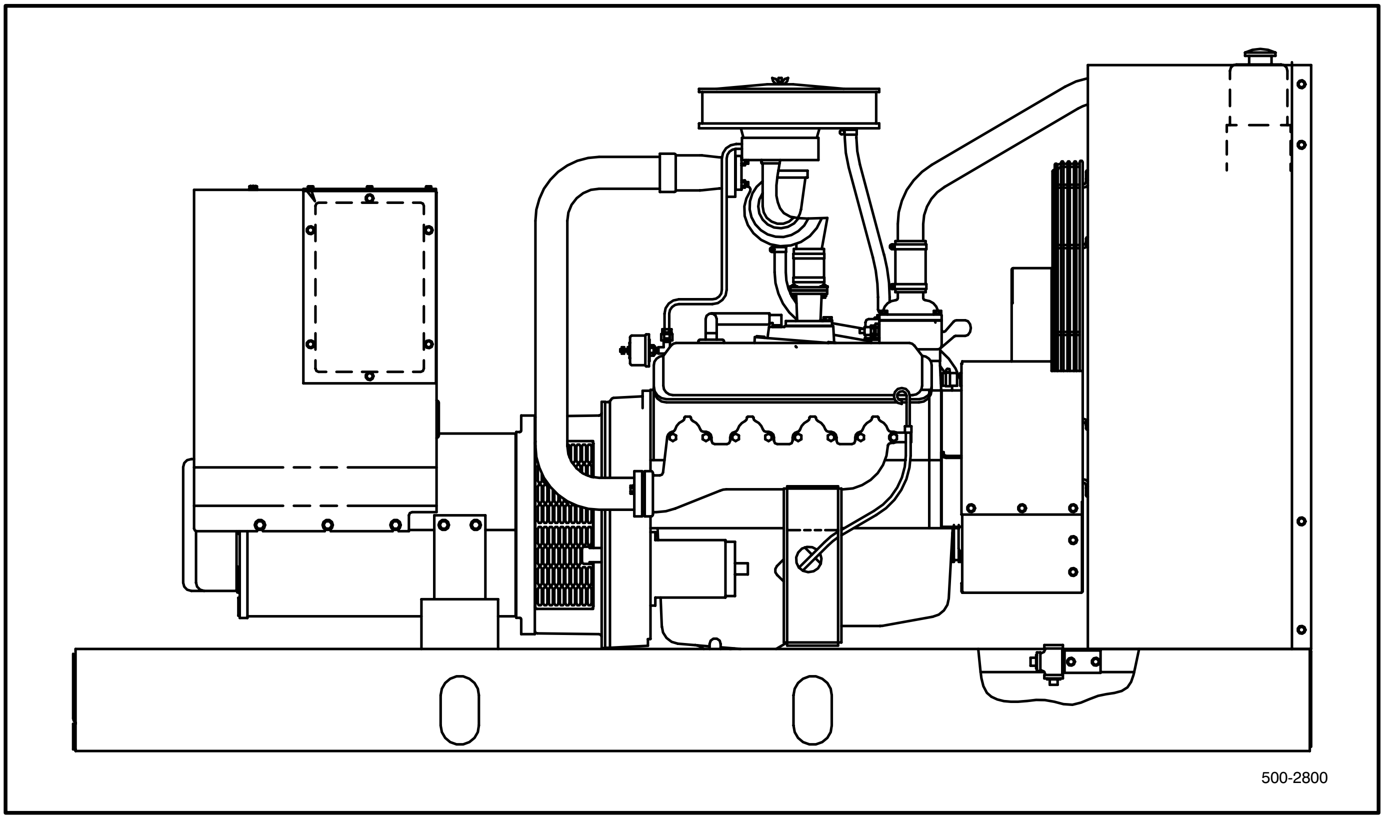


FIGURE 1-1. TYPICAL GENERATOR SET

2. AC Control

GENERAL

The control box is mounted on top of the generator, facing the rear. Figure 2-1 points out the components on the AC control panel. Pages 7-3 through 7-6 show the wiring connections.

STANDARD CONTROL PANEL COMPONENTS

Field Circuit Breaker (CB21) The field circuit breaker protects the generator from over-excitation.

OPTIONAL CONTROL PANEL COMPONENTS

AC Voltmeter (M21) The voltmeter indicates output voltage for the phase selected.

AC Ammeter (M22) The ammeter indicates output amperage for the phase selected. Input to the ammeter is from current transformers CT21, CT22 and CT23.

Phase Selector Switch (S21) The selector switch is used to select the phase for voltage and amperage readings.

Scale Indicator Lamps (DS21 and DS22) The scale indicator lamps indicate whether to read the upper or lower scales of the voltmeter and ammeter.

Frequency Meter (M23) The frequency meter indicates output frequency in Hertz (Hz) and engine speed in RPM.

Wattmeter (M24) The wattmeter indicates output power in kilowatts (kW).

Powerfactor Meter (M25) The powerfactor meter indicates output powerfactor as a percentage of unity powerfactor.

Output Voltage Trimmer (R21) The output voltage trimmer can be used to adjust output voltage plus or minus five percent of nominal voltage.

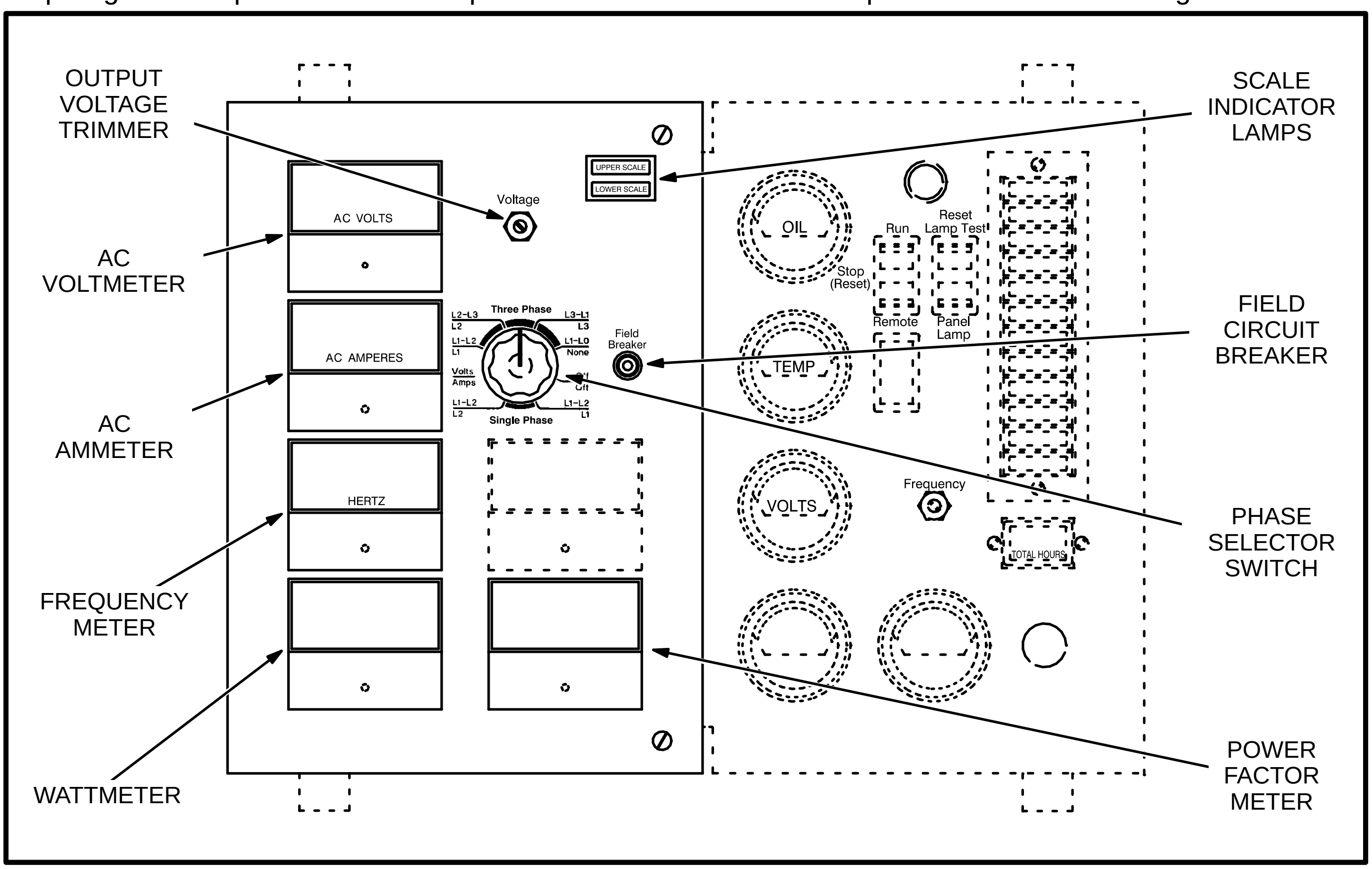


FIGURE 2-1. AC CONTROL PANEL

AUTOMATIC VOLTAGE REGULATOR (AVR) ADJUSTMENTS

The automatic voltage regulator is mounted on the back wall of the control cabinet. It can be adjusted by means of the potentiometers (pots) shown in Figure 2-2. Figures 2-3 and 2-4 show typical voltage regulating circuits.

These measurements and adjustments are done while the set is running and require access to uninsulated high voltage parts in the control and power output boxes.

⚠ DANGER ***HIGH VOLTAGE. Touching uninsulated high voltage parts inside the control and power output boxes can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts.***

For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and wear elbow length insulating gloves intended for hazardous voltages.

Jumper Reconnections

Jumpers provide for reconnections to adapt the voltage regulator to the application. See Figure 2-2. Reconnect the response jumper, if necessary, so that terminal **A** connects to terminal **C** if generator output is 90 kW or less, **B** to **C** if generator output is greater than 90 kW but less than 550 kW and **A** to **B** if output is greater than 550kW. Reconnect the frequency jumper, if necessary, to correspond to the application frequency.

Voltage and Voltage Stability Adjustments

Use the control panel mounted voltage trimmer, if provided, for small voltage adjustments. Measure generator output voltage while the set is running without load at the nominal frequency. If the trimmer does not provide enough adjustment, lock it at its midpoint. Then turn the **VOLTS** pot fully counterclockwise and the **STABILITY** pot to its midpoint. If the red LED (light emitting diode) on the board lights, refer to Jumper Reconnections and to UFRO Adjustments. Then turn the **VOLTS** pot clockwise until rated voltage is obtained. If voltage becomes unstable when a large load is connected, turn the **STABILITY** pot clockwise until voltage is stable. Check and readjust the **VOLTS** pot**,** if necessary, each time the **STABILITY** pot is readjusted.

UFRO Adjustments

The voltage regulator has an under-frequency protection circuit having a threshold frequency that can be preset (typically at 59 Hz for 60 Hz applications and 49 Hz for 50 Hz applications). The red LED on the board lights when frequency dips below the threshold. The threshold frequency is preset by turning the **UFRO** (under frequency roll off) pot clockwise to raise it and counterclockwise to lower it. Determine threshold frequency by lowering generator frequency until the LED lights. Note that Dip and Dwell adjustments, below, are related.

Dip Adjustments

The **DIP** pot adjusts the voltage vs. frequency slope of the generator for frequencies below the threshold preset by the **UFRO** pot. Turning the **DIP** pot clockwise increases the slope (for greater voltage roll off as frequency drops), making it easier for the engine to pick up a large load, but also increasing the voltage dip. The generator voltage vs. frequency slope is the same above and below the threshold frequency when the pot is turned fully counterclockwise.

Dwell Adjustments

The **DWELL** pot times voltage recovery when frequency dips below the preset threshold. Clockwise adjustment increases dwell time. Full counterclockwise adjustment eliminates dwell, in which case, voltage recovery follows engine speed recovery.

Droop Adjustments

The **DROOP** pot is for adjusting the input signal from the droop compensating CT in paralleling applications. **DROOP** is preset at the factory for five percent droop at full load and zero power factor.

V / Trim Adjustments

The **V / Trim** pot is for adjusting the input signal from a VAR / PF controller in utility paralleling applications. Full clockwise adjustment is normal, resulting in maximum sensitivity. The auxiliary controller has no effect when the pot is turned fully counterclockwise.

EXC, OVER V, I / LIMIT, STAB/1and RMS

These pots are factory preset and do not require adjustment.

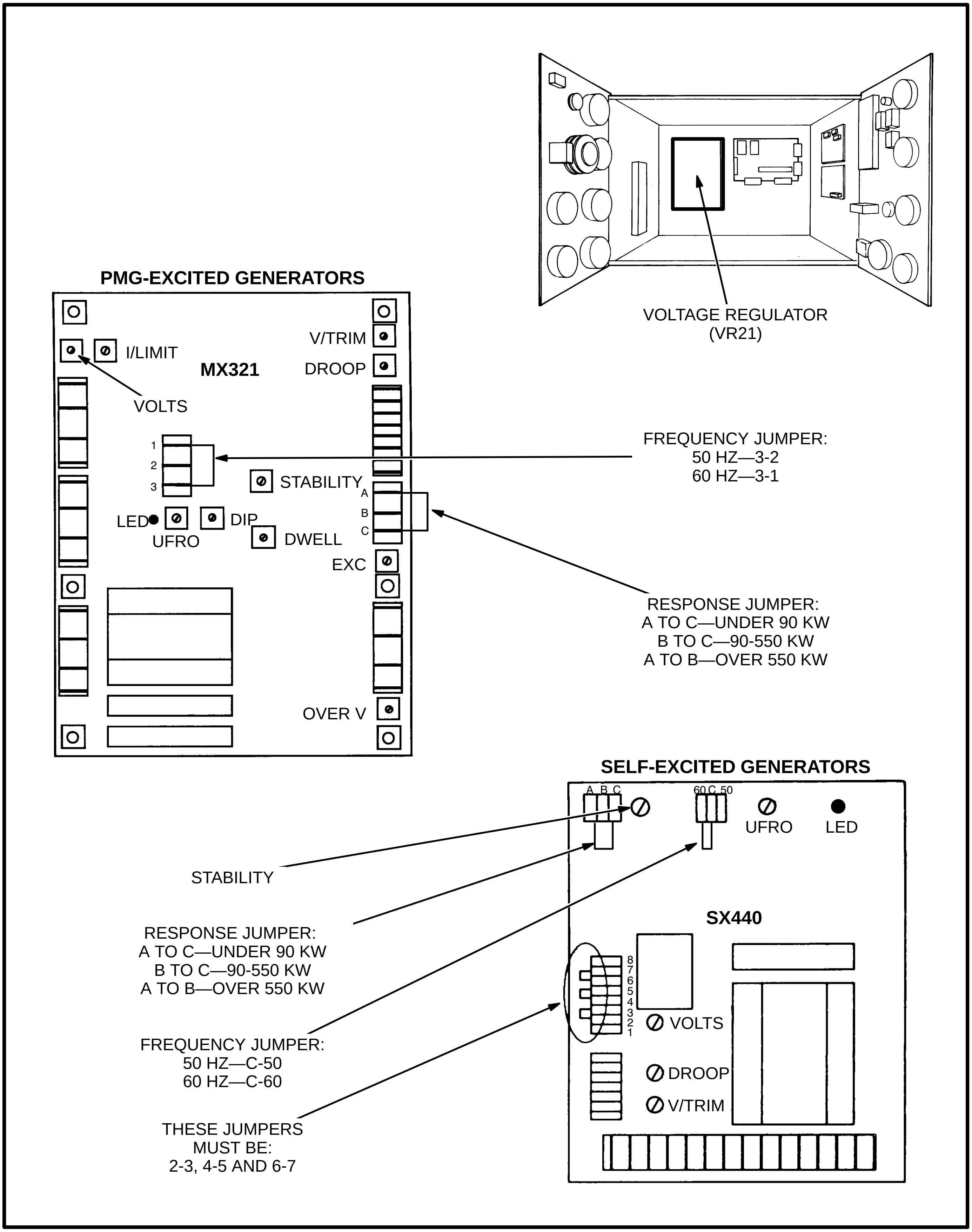
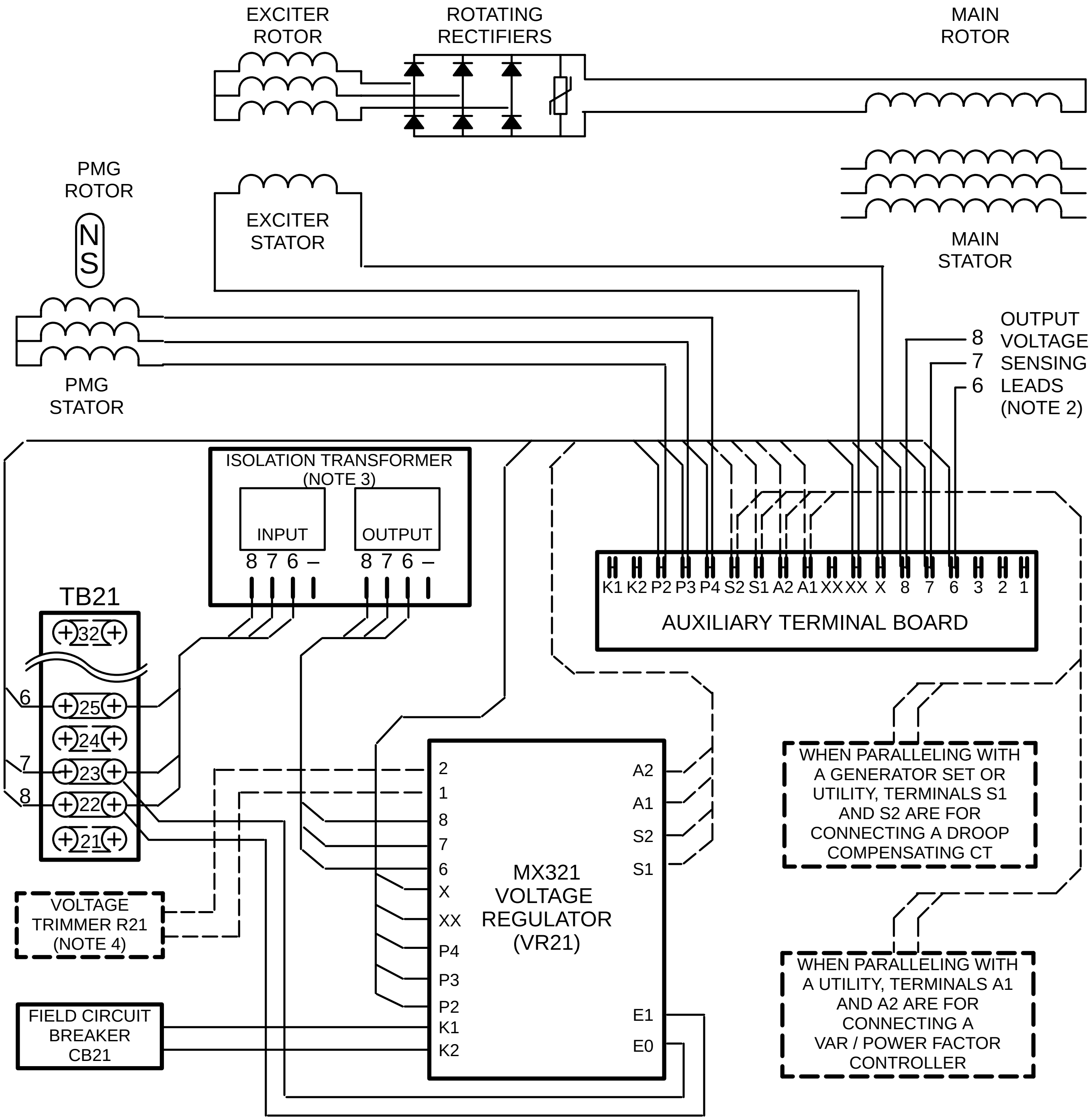


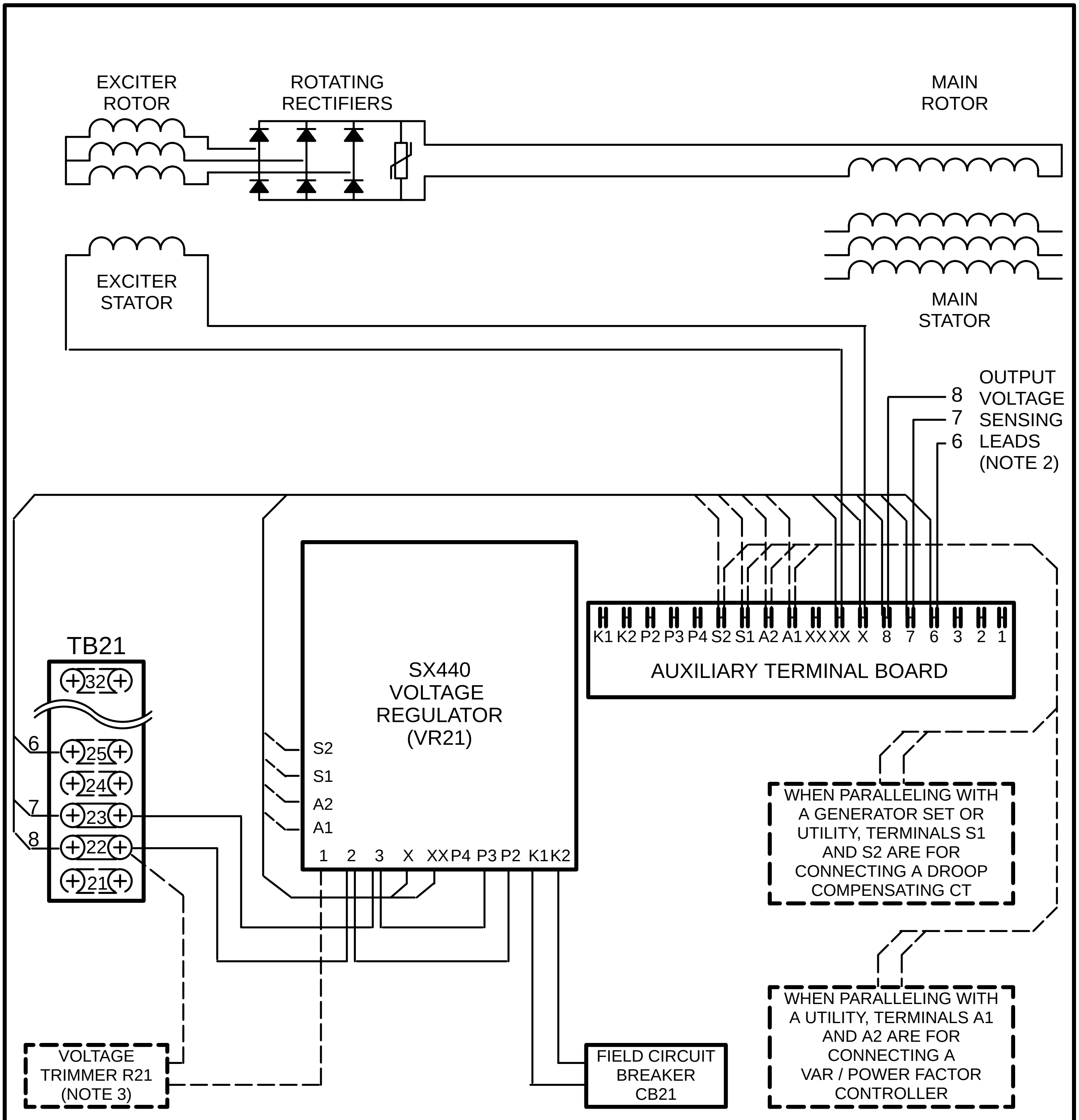
FIGURE 2-2. VOLTAGE REGULATOR ADJUSTMENT POTS AND SELECTION JUMPERS)



— NOTES —

1. Connect like numbered terminals on auxiliary terminal board and voltage regulator.
2. See the appropriate reconnection diagram for connecting sensing leads 6, 7 and 8.
3. When the generator is connected for single-phase output, voltage regulator terminal 6 is not connected to the isolation transformer but is jumpered to voltage regulator terminal 8.
4. There must be a jumper between voltage regulator terminals 1 and 2 when voltage trimmer R21 is not used.

FIGURE 2-3. TYPICAL VOLTAGE REGULATING CIRCUITS FOR PMG-EXCITED GENERATORS



— NOTES —

1. Connect like numbered terminals on auxiliary terminal board and voltage regulator.
2. See the appropriate reconnection diagram for connecting sensing leads 6, 7 and 8.
3. There must be a jumper between voltage regulator terminals 1 and 2 when voltage trimmer R21 is not used.

FIGURE 2-4. TYPICAL VOLTAGE REGULATING CIRCUITS FOR SELF-EXCITED GENERATORS

PRINCIPLE OF GENERATOR OPERATION

1. The generator field (main rotor) is rotated by the engine to induce output current (AC) in the main stator windings.
2. Generator output current is proportional to field strength, which is varied to match the load. Output voltage and frequency are held constant by the voltage regulator and engine governor, respectively.
3. Generator field strength is proportional to field current, which is supplied by the exciter.
4. The exciter field (stator) induces current in the exciter rotor windings. A full wave rectifier bridge (rotating rectifiers) mounted on the exciter rotor converts exciter output (3-phase AC) to DC. The exciter rotor is mounted on the main rotor shaft.
5. Exciter output current is proportional to exciter field current.
6. The automatic voltage regulator (AVR) regulates exciter field current by comparing generator output voltage and frequency with reference values.
7. **PMG-Excited Generators.** Exciter field current is supplied by a PMG (permanent magnet) exciter through the voltage regulator. The PMG consists of a stator and a permanent magnet rotor mounted on the end of the main rotor shaft.
8. **Self-Excited Generators.** Exciter field current is supplied by the generator stator through the voltage regulator. Residual field magnetism initiates “self-excitation” during startups.

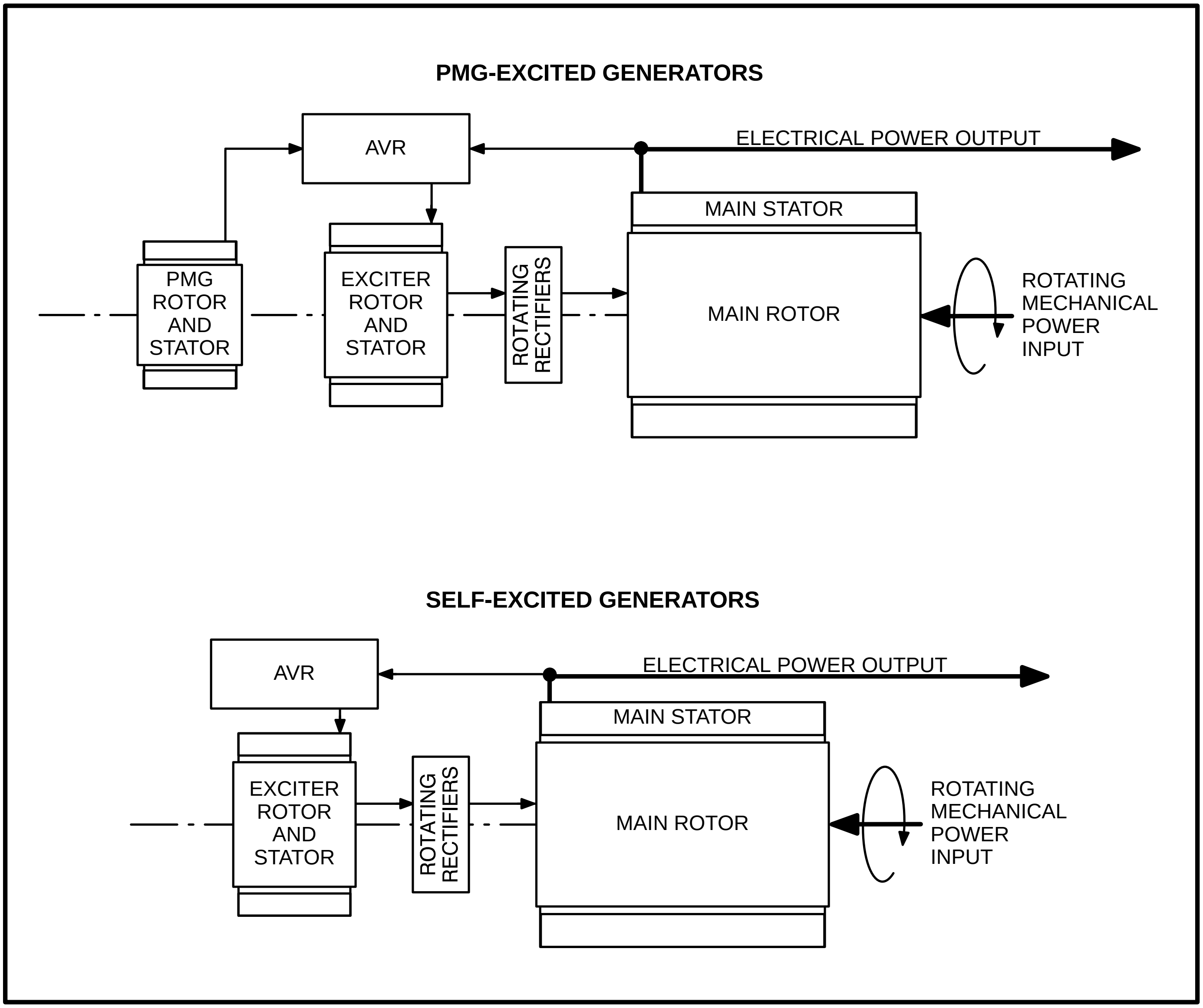


FIGURE 2-5. SCHEMATIC OF GENERATOR OPERATION

3. Engine Control

CONTROL PANEL

The control box is mounted on top of the generator, facing the rear. Figure 3-1 shows the components on the engine control panel.

STANDARD CONTROL PANEL COMPONENTS

Run / Stop / Remote Switch (S12) The switch is pushed to the **Run** position to start and run the generator set and the **Stop** position to stop the set. The **Remote** position allows a remote controller to automatically run the set. The switch must be in the **Stop** position when the reset switch (described next) is used to restore generator set operation following a fault shutdown.

Reset / Lamp Test / Panel Lamp Switch (S11) The switch is pushed to the **Reset** position (momentary contact) to reset the engine control to restore operation following a fault shutdown. The **Run / Stop / Remote** switch must be in the **Stop** position for reset to occur. The **Lamp Test** position (momentary contact) lights all the fault indicator lamps. Replace lamps that do not light. The **Panel Lamp** position lights the panel illumination lamp.

Oil Pressure Gauge (M11) The oil pressure gauge indicates engine oil pressure.

Coolant Temperature Gauge (M12) The coolant temperature gauge indicates engine coolant temperature.

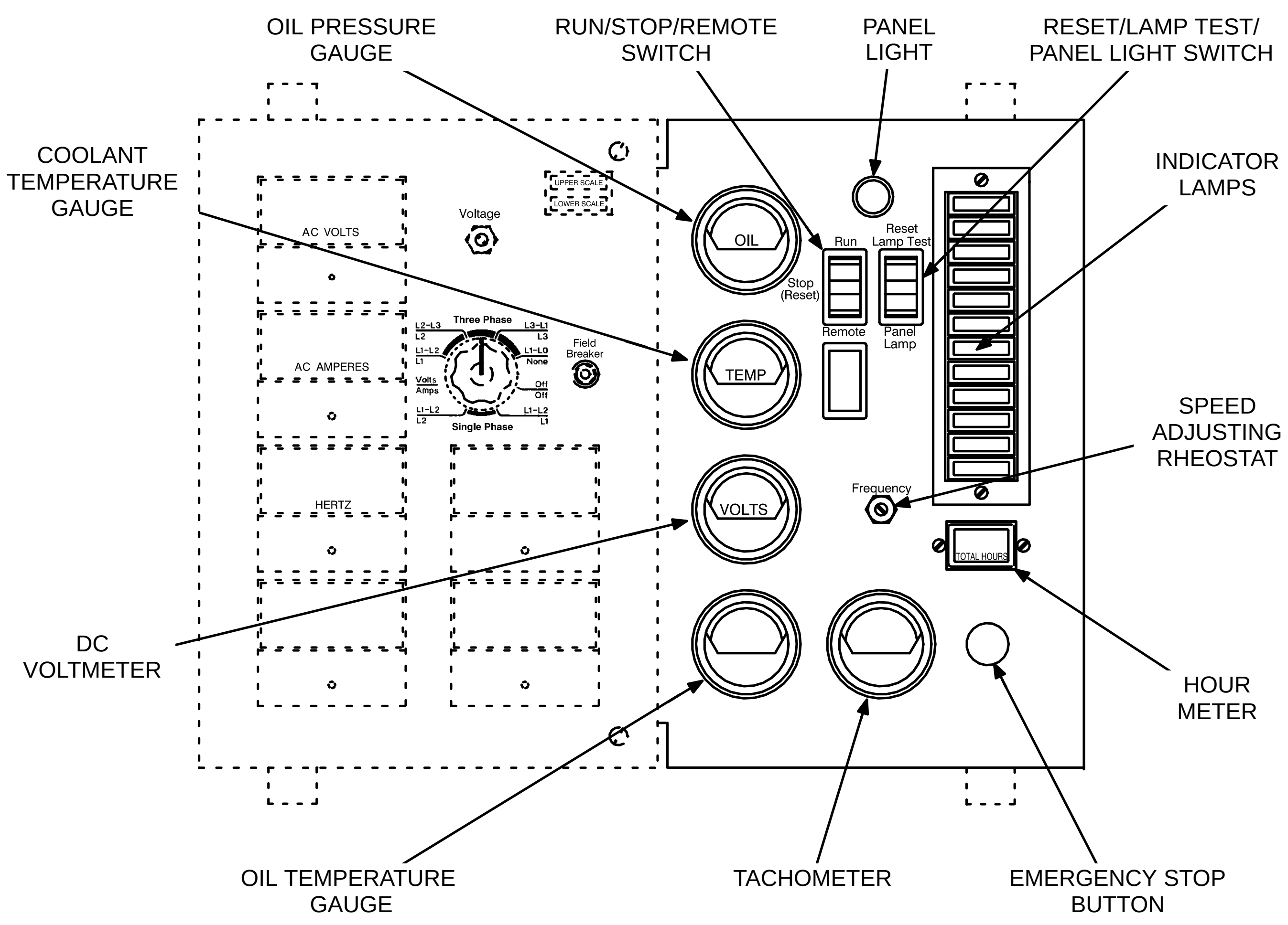


FIGURE 3-1. ENGINE CONTROL PANEL

DC Voltmeter (M13) The DC voltmeter indicates voltage across the battery terminals during operation.

Hour Meter (M14) The hour meter indicates the accumulated number of hours the set has run. It cannot be reset.

Panel Lamp (DS11) The panel lamp illuminates the control panel.

Detector-7 Fault and Status Indicator Lamps (A12)

- **Run (Green)** This lamp indicates that the generator set is running and that the starter has been disconnected.
- **Pre Low Oil Pressure (Yellow)** This lamp indicates that engine oil pressure is abnormally low (less than 30 psi).
- **Low Oil Pressure (Red)** This lamp indicates that the engine shut down because of excessively low engine oil pressure (less than 25 psi).
- **Pre High Engine Temperature (Yellow)** This lamp indicates that engine coolant temperature is abnormally high (greater than 205° F [97° C]).
- **High Engine Temperature (Red)** This lamp indicates that the engine shut down because of excessively high engine coolant temperature (greater than 215° F [102° C]).
- **Overcrank (Red)** This lamp indicates that the engine shut down because it did not start during the timed cranking period (approximately 75 seconds, including two rest periods).
- **Overspeed (Red)** This lamp indicates that the engine shut down because of overspeed.

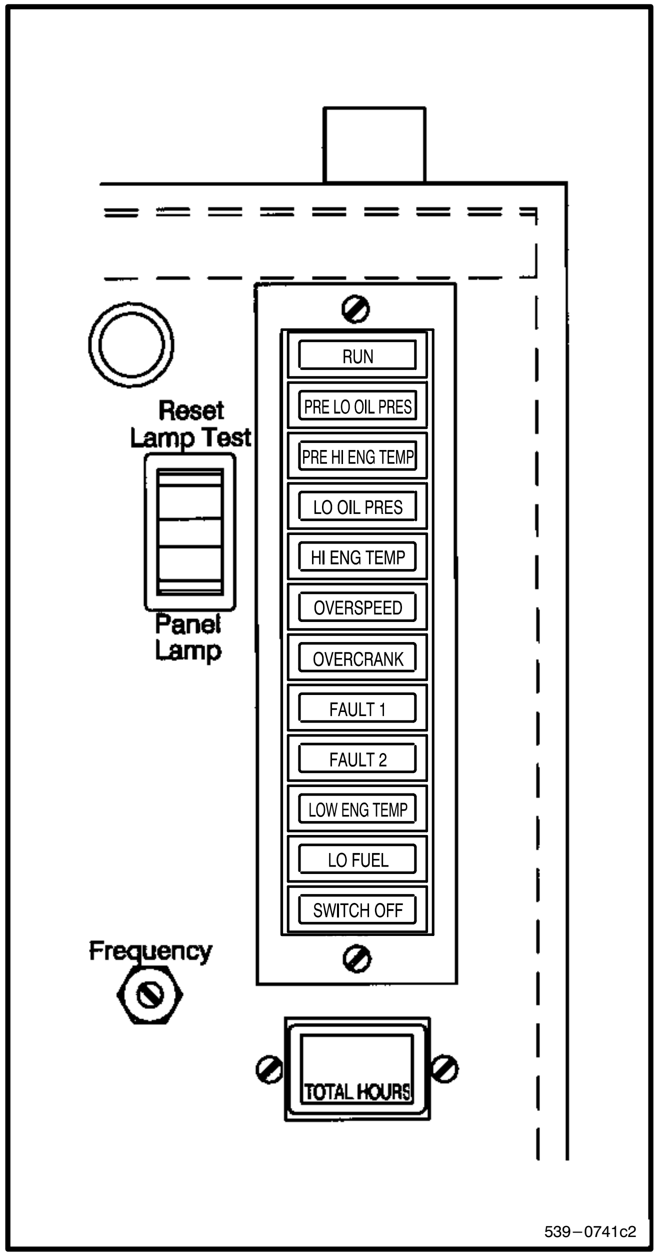


FIGURE 3-2. DETECTOR-12 INDICATOR LAMPS

OPTIONAL CONTROL PANEL COMPONENTS

Oil Temperature Gauge (M15) The oil temperature gauge indicates engine oil temperature.

Tachometer (M16) The tachometer indicates engine speed in RPM.

Speed Adjusting Rheostat The speed adjusting rheostat is used to adjust engine speed from the control panel (an option with the optional electric governor).

Emergency Stop Button (S14) The emergency stop button is a red, push-in switch used to stop the engine. The button lights up when it is pushed in. The button has to be pulled out and the engine control reset to restore operation.

Low Coolant Level Cutout Switch When coolant level in the radiator top tank falls below the switch sensor, the switch closes the circuit to ground. This switch may be connected in parallel with the high engine temperature cutout switch to shut down the engine and light the **High Engine Temperature** lamp or in parallel with the pre-high engine temperature switch to light the **Pre High Engine Temperature** light only.

Detector-12 Fault and Status Indicator Lamps (A12) The Detector-12 control panel has the five following indicator lamps in addition to the standard seven.

- **Low Engine Temperature (Yellow)** This lamp indicates that engine temperature is less than 70° F, and the possibility that the engine might not start.
- **Low Fuel (Yellow)** This lamp indicates that the fuel level in the supply tank has dropped to less than the reserve necessary to run the set at full load for the prescribed number of hours. The customer has to make connections to use this lamp.
- **Fault 1 (Red)** This lamp indicates that the engine shut down because of a system fault. The customer has to make connections to use this lamp. The lamp is a part of a 10 second time delay shutdown circuit. The customer can make reconnections for non-timed shutdown. See Engine Control Monitor (ECM).
- **Fault 2 (Red)** This lamp indicates that the engine shut down because of a system fault. The customer has to make connections to use this lamp. The lamp is part of a non-time delay shutdown circuit. The customer can make reconnections for 10 second time delay shutdown. See Engine Control Monitor (ECM).
- **Switch-off (Flashing Red)** This lamp indicates that the **Run / Stop / Remote** switch is in the **Stop** position, which prevents remote, automatic operation.

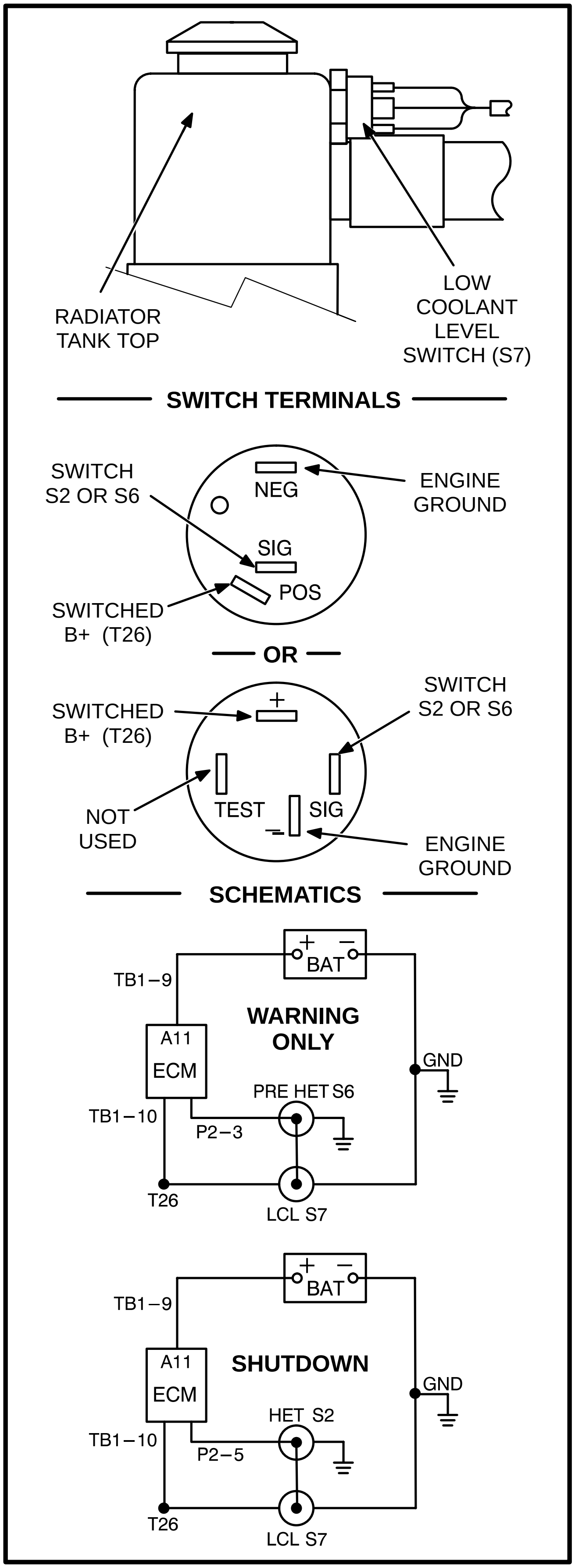


FIGURE 3-3. LOW COOLANT LEVEL SWITCH

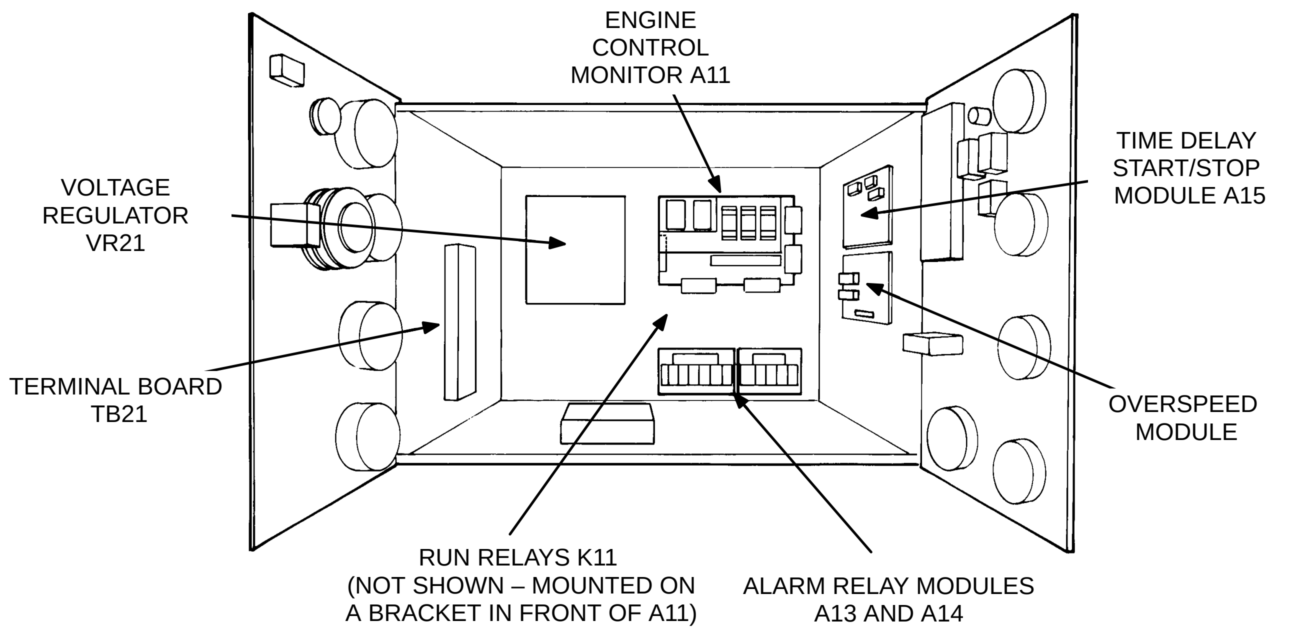


FIGURE 3-4. ARRANGEMENT OF COMPONENTS INSIDE THE CONTROL BOX

CONTROL BOX INTERIOR

Figure 3-4 shows the arrangement of components inside the control box, including the engine control monitor and some of the auxiliary components under following headings.

ENGINE CONTROL MONITOR (A11)

The heart of the engine control system is the engine control monitor (ECM). It is a printed circuit board assembly mounted on the back wall of the control box. It starts and stops the engine in response to the control panel switches, engine sensors and remote control signals. Figure 3-5 shows the newer ECM board used in current production and as a direct replacement for older boards. The boards are distinquishable from each other in that the newer boards have automotive-type fuses and the older boards have cartridge-type fuses.

Terminals and Connectors

See Pages 7-7 through 7-14 for the appropriate connection and schematic drawings for the DC control system. See Page 7-19 for typical customer connections at terminal boards **TB1** and **TB2** on the ECM and page 7-20 if the set is also equipped with the auxiliary relay board.

Fuses

The ECM has five replaceable fuses to protect it from overloads and groundfaults. They are:

F1 Starter solenoid circuit, 20 amps

F2 Fuel solenoid (switched B+) circuits, 20 amps

F3 Continuous B+ out to remote circuits, 15 amps

F4 ECM circuits, 5 amps

F5 Engine gauge circuits, 5 amps.

Function Selection Jumpers

Newer ECM boards have six selection jumpers that can be repositioned to provide the following timed or non-timed warnings or timed or non-timed shutdowns with warnings:

W1 Jumper Position (jumper **W8** must be in the **B** position):

- **A** Non-timed warning under **FLT 2** conditions.
- **B** Non-timed shutdown and warning under **FLT 2** conditions.
- **C** Timed warning under **FLT 2** conditions.
- **D** Timed shutdown and warning under **FLT 2** conditions.

W2 Jumper Position (jumper **W9** must be in the **B** position):

- **A** Non-timed warning under **FLT 1** conditions.
- **B** Non-timed shutdown and warning under **FLT 1** conditions.
- **C** Timed warning under **FLT 1** conditions.
- **D** Timed shutdown and warning under **FLT 1** conditions.

W6 Jumper Position:

- **A** Warning under **Pre-High Engine Temperature** conditions.
- **B** Shutdown and warning under **Pre-High Engine Temperature** conditions.

W7 Jumper Position:

- **A** Warning under **Pre-Low Oil Pressure** conditions.
- **B** Shutdown and warning under **Pre-Low Oil Pressure** conditions.

W8 Jumper Position:

- **A** Warning while running or during standby under **FLT 2** conditions.
- **B** Allows selection of functions with **W1** jumper.

W9 Jumper Position:

- **A** Warning while running or during standby under **FLT 1** conditions.
- **B** Allows selection of functions with **W2** jumper.

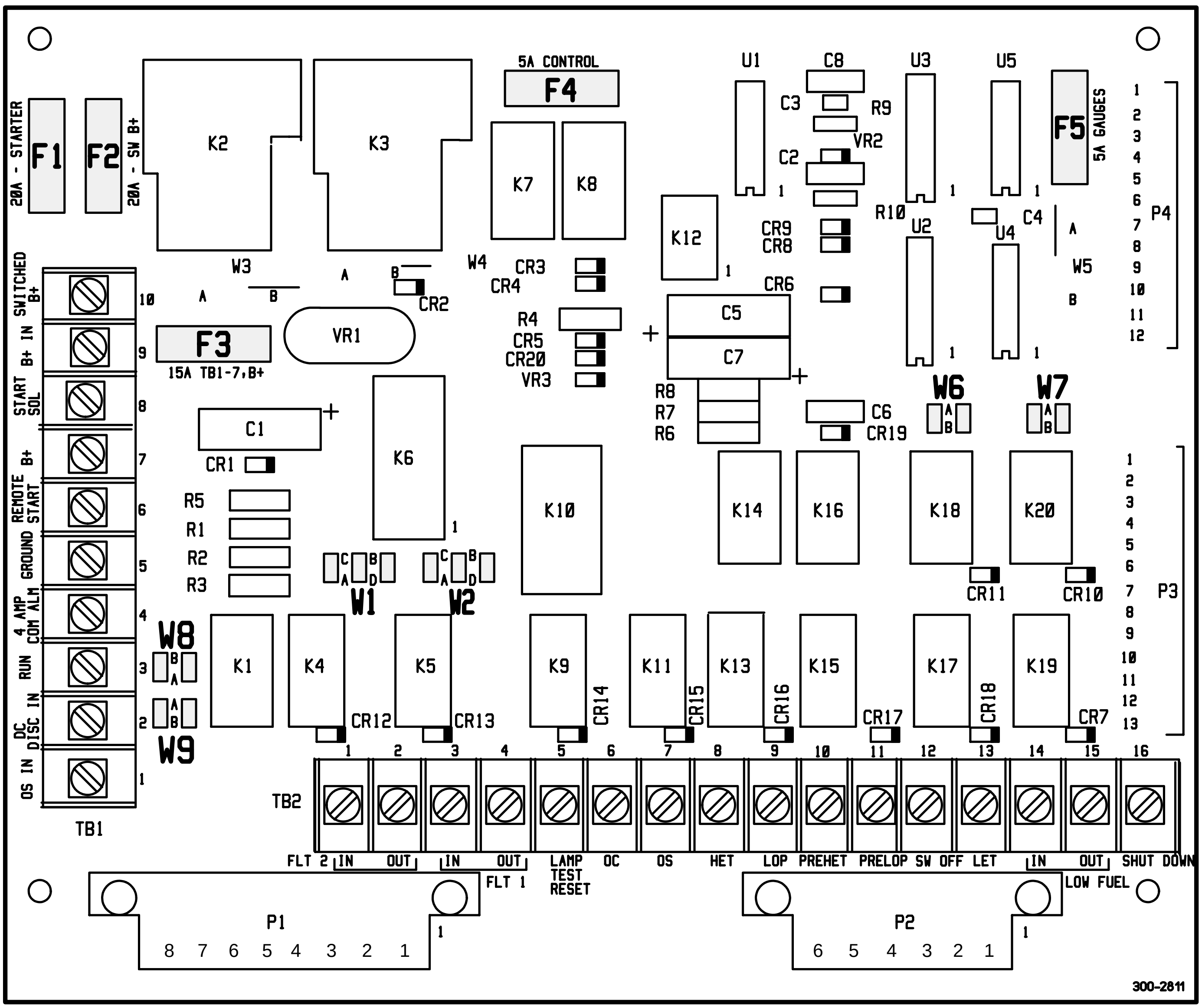


FIGURE 3-5. ENGINE CONTROL MONITOR FUSES AND FUNCTION SELECTION JUMPERS

ENGINE SENSORS

Figure 3-6 shows the locations of the gauge senders and the coolant temperature and oil pressure sensing switches to which the ECM responds. The switches function by closing the fault or warning circuit to the engine chassis ground (battery negative [-]).

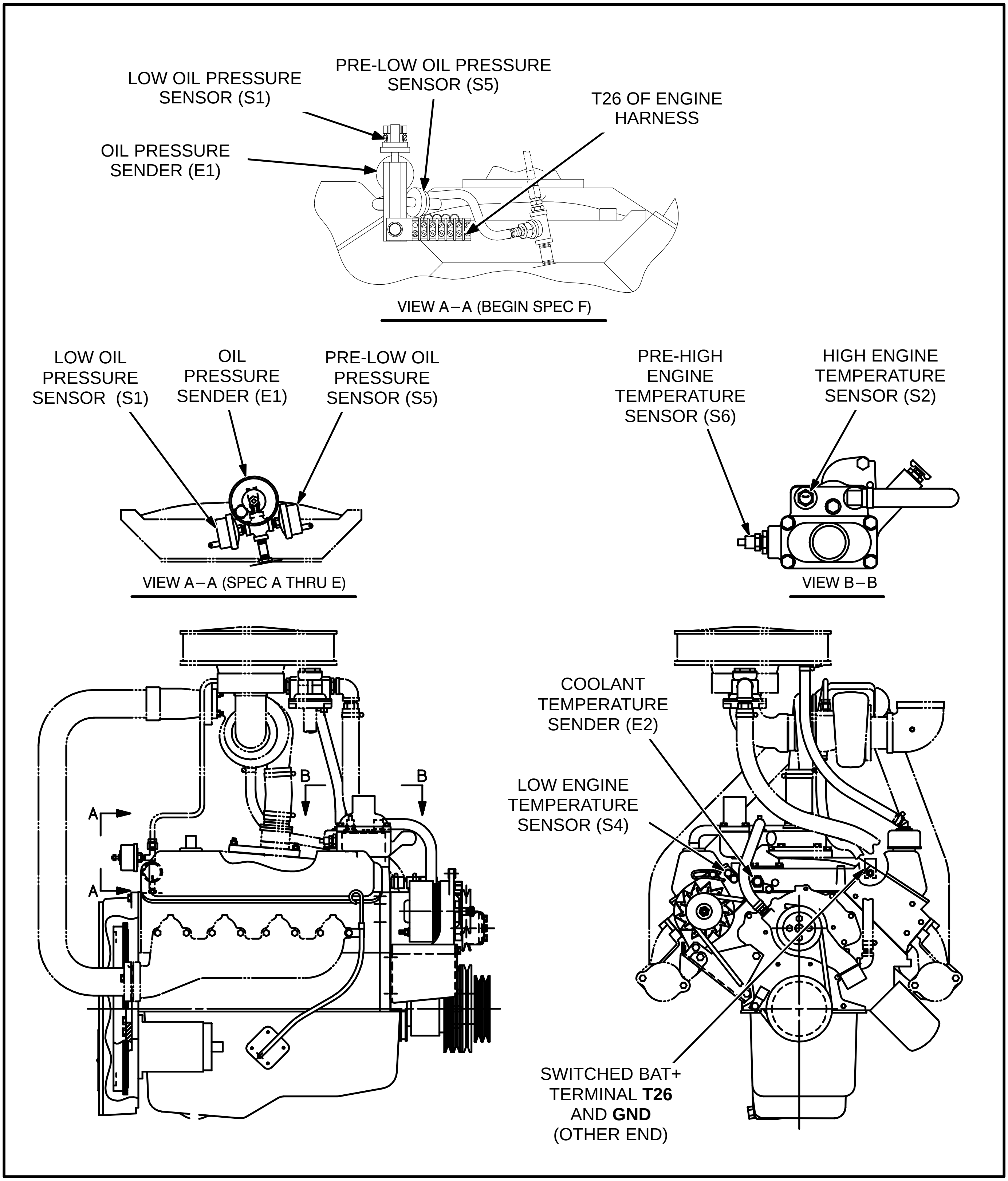


FIGURE 3-6. ENGINE SENSOR LOCATIONS

AUXILIARY CONTROL COMPONENTS

The set might be equipped with one or more of the following components.

Mechanical Overspeed Switch (Standard)

The mechanical overspeed switch is bolted to the end of the generator rotor shaft.

1. Check overspeed cutout RPM and turn the adjustment screw, if necessary, so that shutdown occurs within the following RPM ranges:
   60 Hz Sets . . . . 2000 to 2200 RPM
   50 Hz Sets . . . . 1800 to 2100 RPM
2. Replace the switch if the cutout speed adjustment results in an air gap between the magnet and the fly arm of less than 0.005 inches (0.13 mm).
3. Torque the center rotor bolt to 40 ft-lbs (54 Nm) when replacing the switch.

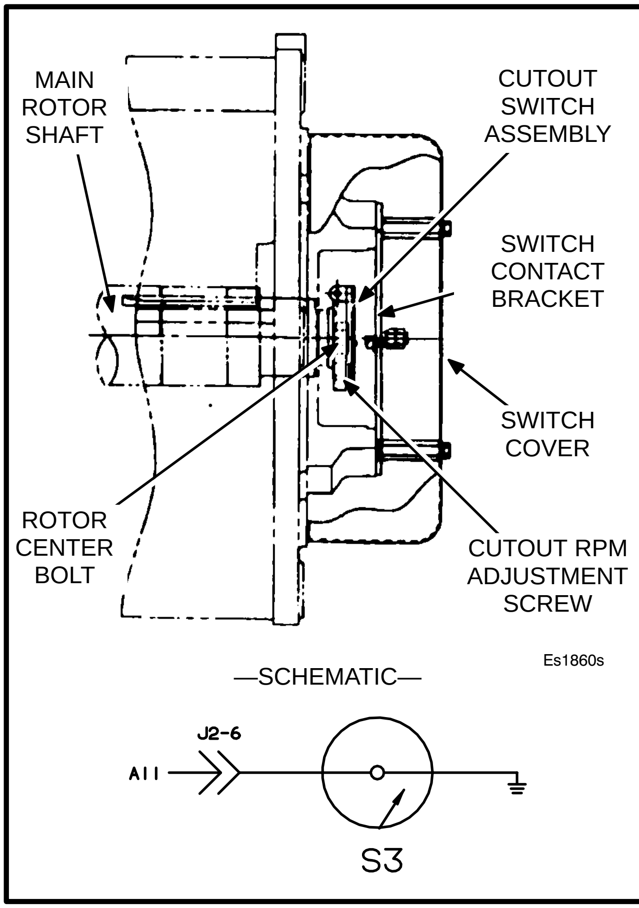


FIGURE 3-7. MECHANICAL OVERSPEED SWITCH

Electronic Overspeed Module (Optional)

PMG-excited generators are equipped with an electronic overspeed module in the control box. The module senses PMG output frequency to determine generator speed (frequency). Adjust the overspeed (**HIGH**) pot to cut out at 1800 to 1900 RPM for 50 Hz sets and 2100 to 2200 RPM for 60 Hz sets. **MODE** switch must be set to zero.

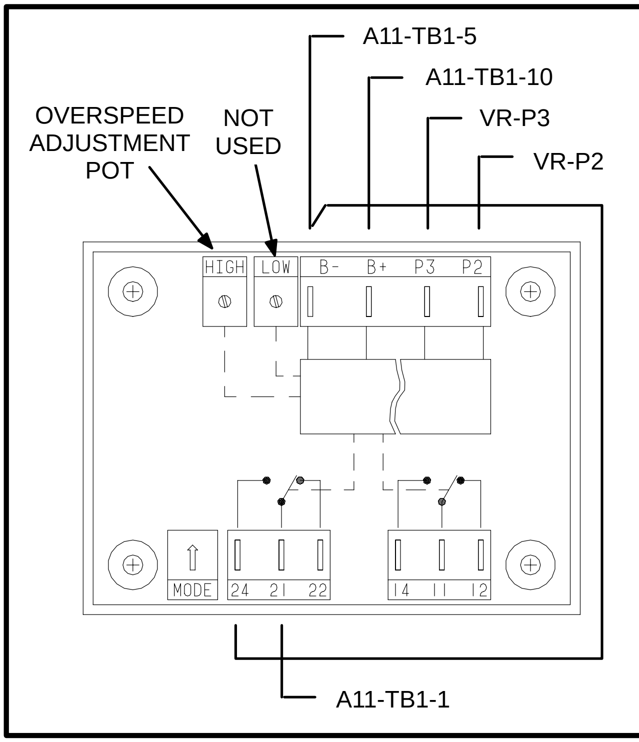


FIGURE 3-8. ELECTRONIC OVERSPEED MODULE

Run Relays (K11)

The set can be equipped with one to three 3-pole, double-throw relays to control auxiliary equipment such as fans, pumps, and motorized air dampers. The relays are mounted on a standoff bracket in front of the ECM.

The contacts are rated:

- 10 amps at 28 VDC or 120 VAC, 80% PF
- 6 amps at 240 VAC, 80% PF
- 3 amps at 480 VAC, 80% PF

The set might instead be equipped with an auxiliary relay board. If so, see Auxiliary Relay Board (ARB).

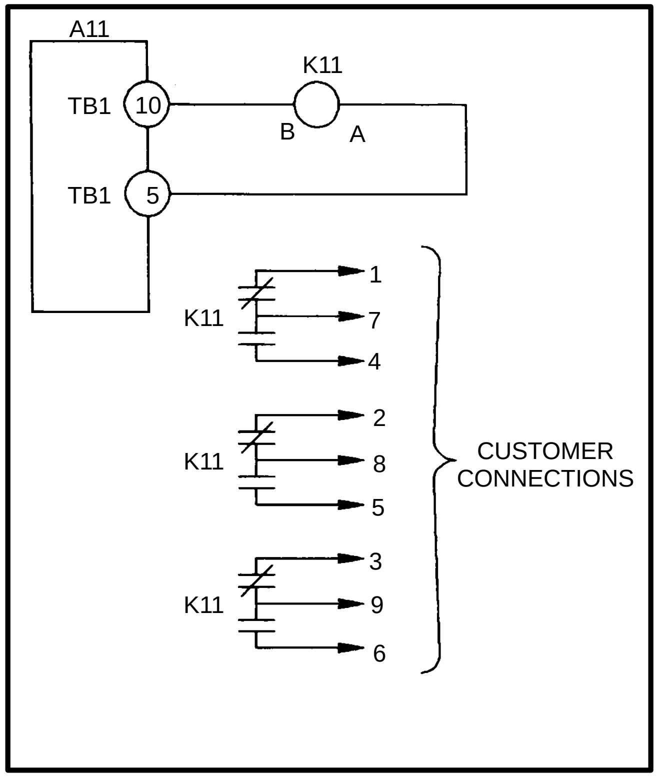


FIGURE 3-9. RUN RELAYS

Alarm Relay Modules (A13 and A14)

The set can be equipped with relay modules to interface with a remote annunciator that is powered independently of the control circuit of the set. Sets with Detector-7 need module A13 and sets with Detector-12, modules A13 and A14.

These are all normally open contacts and they are rated:

- 15 amps at 250 VAC
- 15 amps at 30 VDC

The set might instead be equipped with an auxiliary relay board. If so, see Auxiliary Relay Board (ARB).

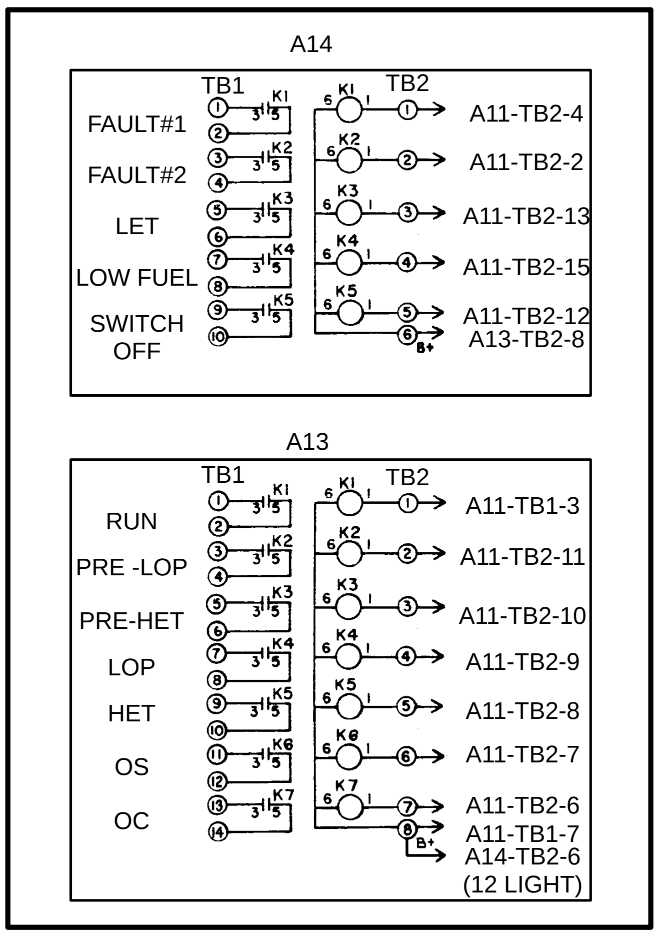


FIGURE 3-10. ALARM RELAY MODULES

Auxiliary Relay Board (ARB)

The following describes the design/functional criteria for the auxiliary relay board (ARB) with a Detector-7 or -12 Genset control. The board is mounted directly on top of the ECM using standoffs and has access holes for the fuses located on the ECM. There are two versions of the ARB; with and without the set of 12 Fault relays (Figure 3-11). Page 7-20 is a detailed connection diagram for the ARB.

The set might instead be equipped with separate run and alarm relay modules. If so, see Run Relay (K11) and Alarm Relay Modules (A13 and A14).

Terminal Blocks:

TB1 – ARB TB1 and ECM TB1 are identically numbered and provide the same remote control connection points. Note that additional terminals are provided for terminals 5, 7, and 10 of ARB TB1.

TB2 through TB5 – Connection points for relays K1 through K3. TB2 provides the N/O and N/C connections (three form 'C' contacts for each relay). TB3 through TB5 provide the common connection points (TB3 for K1, TB4 for K2 and TB5 for K3).

TB6 and TB7 – Connection points for fault relays K4 through K15. Three terminals are provided for each relay, which are labeled COM, N/C, N/O.

Plug-In Relays (K1, K2, K3):

The ARB can be equipped with one to three 3-pole, double-throw relays. These relays (K1, K2, K3) are field changeable plug-in relays for easy field addition and replacement.

The relay contact ratings are:

- 10 amps at 28 VDC or 120 VAC, 80% PF
- 6 amps at 240 VAC, 80% PF
- 3 amps at 480 VAC, 80% PF

Each relay can be operated as a RUN, COMMON ALARM, or ISOLATED COIL with the changing of a jumper.

Jumper Positions for Plug-In Relays:

Jumpers W1, W2 and W3 perform the same functions for their respective relays, W1 for relay K1, W2 for relay K2, and W3 for relay K3. They can be located in any of 3 positions (A, B, C) independently of each other.

Jumper Position A (Run): The relay operates as a Run relay, energizing when SW B+ is applied from the ECM.

Jumper Position B (Common Alarm): The relay operates as a Common Alarm relay. The relay energizes any time there is an engine shutdown. This signal is provided from the ECM.

Jumper Position C (Isolated): The relay operates as an Isolated relay. The relay coil is energized by a customer applied B+ signal through the terminal block; TB3-1 for relay K1, TB4-1 for relay K2, and TB5-1 for relay K3.

Jumpers W11, W12, and W13 perform the same functions for their respective relays; W11 for relay K1, W12 for relay K2, and W13 for relay K3. They can be located in two different positions (A, B) independently of one another.

Jumper Position A: The relay operates isolated from the board. The customer provides the circuit completion through terminal block; TB3 for relay K1, TB4--5 for relay K2, and TB5-5 for relay K3. The customer can operate the relay with switched ground logic or use this relay in the middle of more complex logic circuits if needed.

Jumper Position B: The relays operate with the coils connected to ground through the board connections. The coil will require a B+ signal to energize with the jumper in this position.

Fault Relays (K4 through K15):

These optional relay modules are used to operate a remote alarm annunciator that has an independent power source. This allows the use of either AC or DC for alarm drives. The relays are energized through the latching relays on the ECM and provided N/O and N/C contacts for each external alarm connection.

The 12 relays with form 'C' contacts are rated:

- 10 Amp, 120 VAC
- 10 Amp. 30 VDC

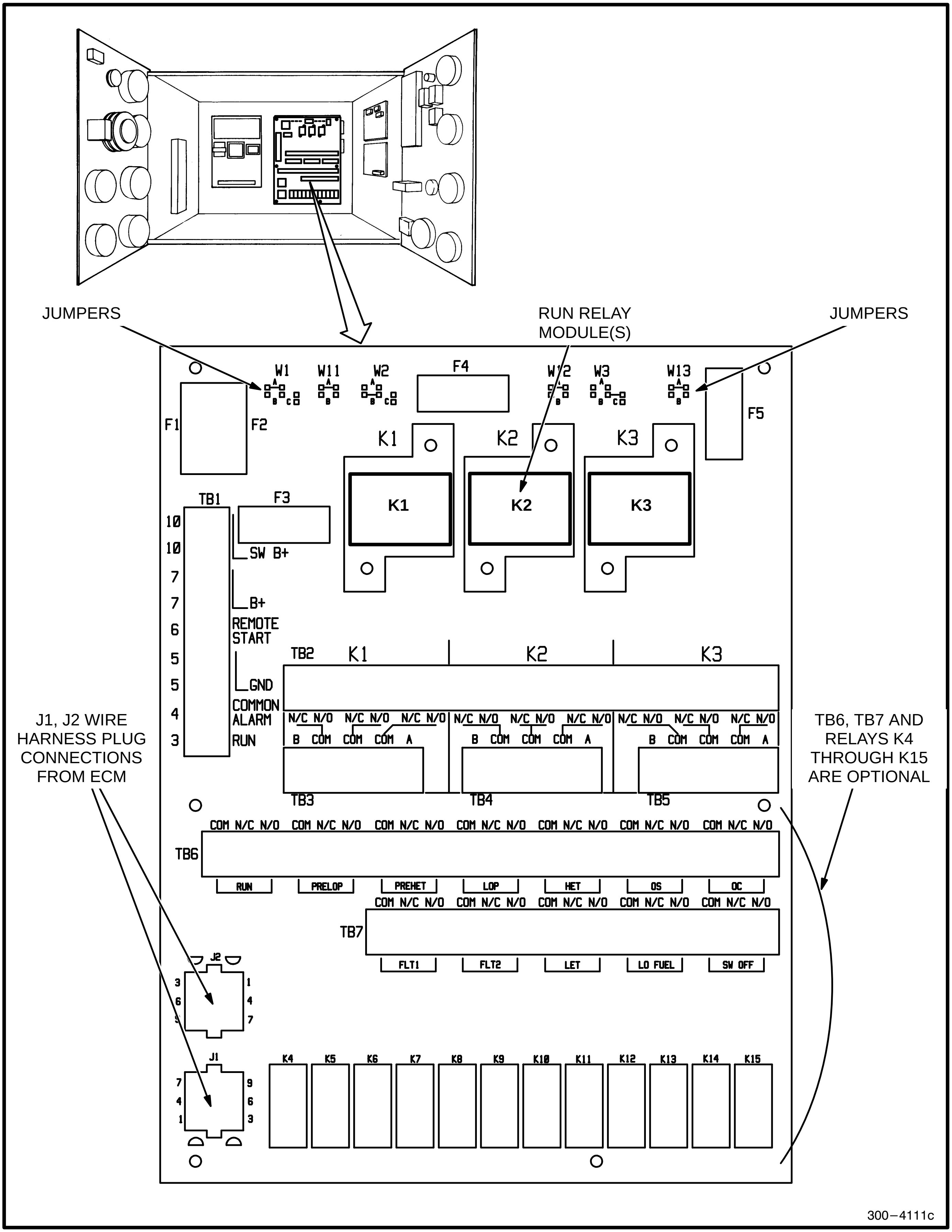


FIGURE 3-11. AUXILIARY RELAY BOARD (ARB)

Over / Under Voltage Module (A17)

The set can be equipped with an adjustable voltage-sensitive relay usually connected into the **Fault 1** circuit (Detector-12 controls only) to shut down the set when the output voltage is over or under nominal voltage by the preselected percentage (typically 10 percent over and under).

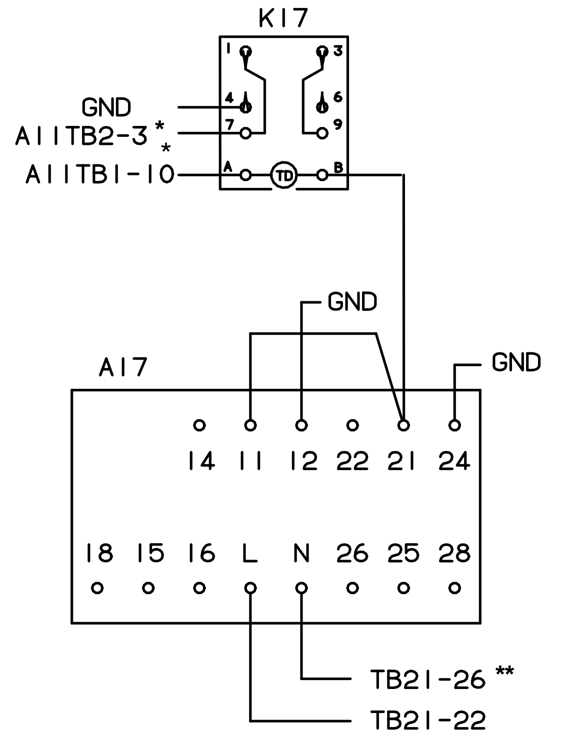
With the module is an adjustable time delay relay (**K17**) to prevent nuisance tripping. An adjustment of 25 percent is equivalent to about 2.5 seconds delay.

Recalibrate the module as follows before installing it on 139/240 VAC or 277/480 VAC sets.

⚠WARNING ***HIGH VOLTAGE. Touching uninsulated high voltage parts inside the control panel box can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts.***

For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and wear elbow length insulating gloves intended for hazardous voltages.

1. Remove the two screws that secure the top to the case of the module and withdraw the top assembly.
2. Adjust the **SET** pot for the **UNDER** setpoint on the face of the top assembly to 75 percent.
3. Apply single-phase, 60 Hertz, 104.25 VAC across terminals **L** and **N**.
4. Adjust pot **R25** on the PC board until the relay trips (de-energizes).
5. Adjust the **SET** pot for the **OVER** setpoint on the face of the top assembly to 125 percent.
6. Apply single-phase, 60 Hertz, 173.75 VAC across terminals **L** and **N**.
7. Adjust pot **R26** on the PC board until the relay trips (energizes).
8. Repeat the above steps until no adjustments are necessary.
9. Reassemble the module.
10. On the module nameplate mark out the factory calibration value for monitored voltage (120 V) and write in **139 V**.



* CONNECTED TO **TB11-45** WHEN GENERATOR IS PARALLELED.

** CONNECTED TO GENERATOR LEAD **LO** WHEN THE GENERATOR IS CONNECTED FOR SINGLE PHASE.

FIGURE 3-12. OVER / UNDER VOLTAGE MODULE

Over / Under Frequency Module (A19)

The set can be equipped with an adjustable frequency-sensitive relay to shut down the set when the output frequency (Hz) is over or under nominal frequency by the preselected amount. It is usually connected into the **Fault 2** circuit (Detector-12 controls only) if the over / under voltage module is also provided. Set points are typically 5 Hertz over and under nominal frequency (50 or 60 Hertz) and reset points 3 Hertz over and under.

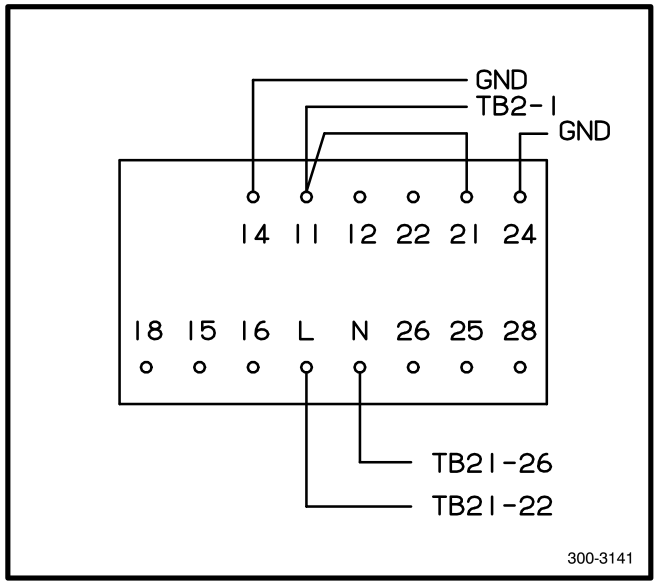


FIGURE 3-13. OVER / UNDER FREQUENCY MODULE

Time Delay Start / Stop Module (A15)

The set can be equipped with a module to delay starting and stopping when the start and stop signals are received from the remote controller. It is adjustable to delay starts from 1 to 15 seconds to prevent nuisance starts in installations where momentary power interruptions are frequent. It is adjustable to delay stops 1 to 30 minutes to allow the prime source of power time to stabilize.

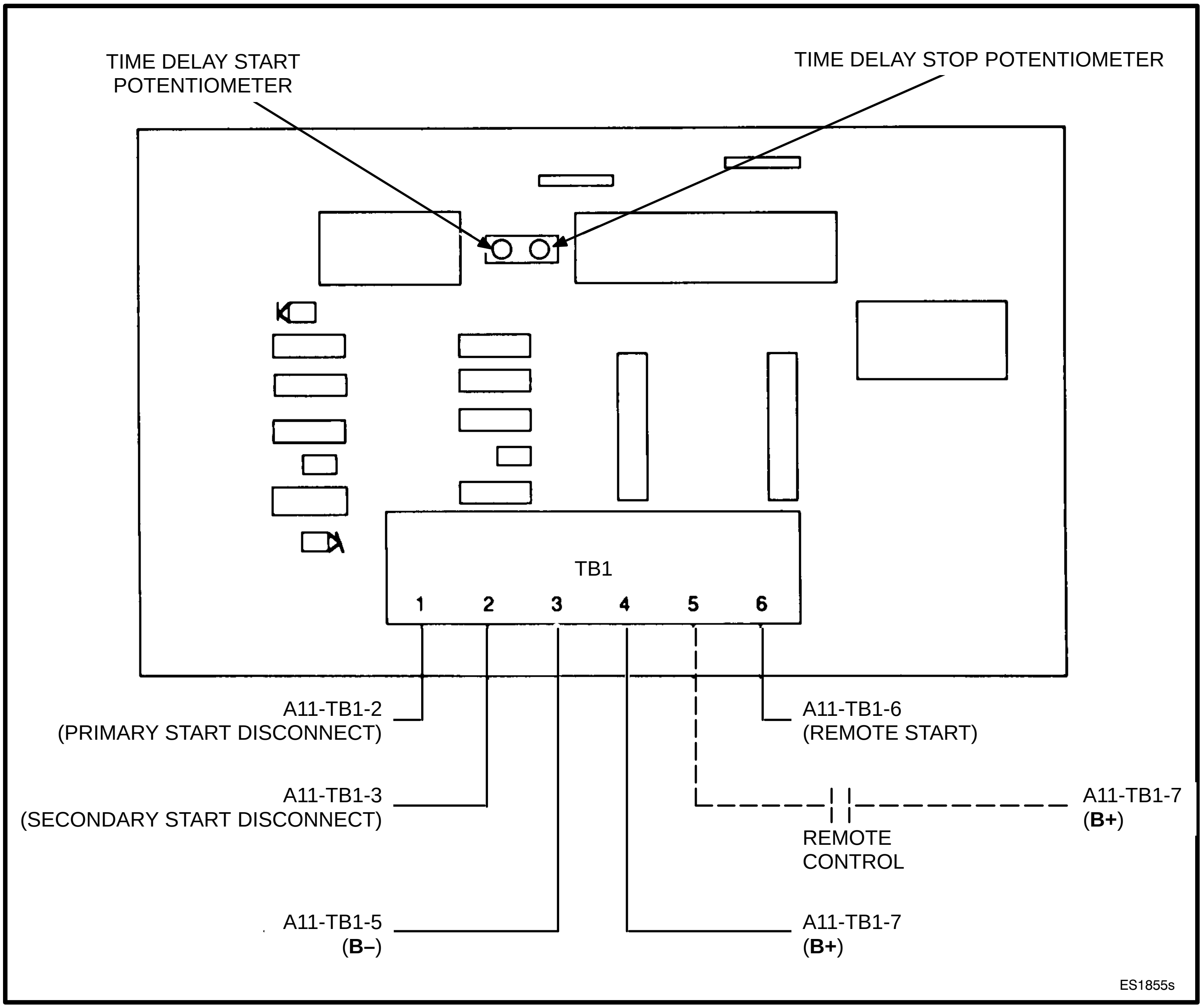


FIGURE 3-14. TIME DELAY START / STOP MODULE

SEQUENCE OF OPERATION

The sequence of operation is as follows. Refer to the schematic on Page 7-8, 7-10, 7-12, or 7-14, as appropriate.

1. The ECM is powered by cranking battery voltage (24 VDC). Terminal **TB1-9** is connected to battery positive (+) and connector **P1-6** to battery negative (-).
2. The starting cycle begins when relay **K7** is powered, either manually by pushing the panel **Run** switch, or automatically by a remote controller connected at terminal **TB1-6**. (The panel switch must be in the **Remote** position for remote, automatic operation.)
3. Relay **K7** powers relays **K2** and **K3**.
4. Relay **K2** powers the engine gauges and terminal **TB1-10**, to which the fuel solenoid and ignition module are connected.
5. Relay **K3** powers terminal **TB1-8** to which starter relay **K4** is connected. Engine cranking begins.
6. The engine starts and runs up to governed speed in a matter of seconds.
7. The starter is disconnected when engine speed gets to about 500 RPM. This is done by relay **K10** or **K14**, whichever acts first to open the circuit powering relay **K3**.
8. Relay **K10** is powered by the generator output voltage (120 VAC) through plug-in connectors **P1-1** and **P1-2**. The remote **Run** indicator lamp should light (connected through terminal **TB1-3)**.
9. Relay **K14** is powered by the engine-driven battery charging alternator (24 VDC) through plug-in connector **P1-3**. The panel **Run** indicator lamp should light. Relays K10 and K14 are redundant.*
10. Relays **K2** and **K3** are deenergized (by latching relay **K6**) causing shutdown to occur if the engine does not start within 75 seconds. The **Overcrank** indicator lamp lights and common alarm terminal **TB1-4** is powered.

    The ECM has a cycle crank feature whereby the engine is cranked for three 15 second periods alternated with two 15 second rest periods.

11. Relay **K3** is deenergized (by latching relay **K6**) causing shutdown to occur during operation when a low oil pressure, high engine temperature or engine overspeed condition is sensed or the optional emergency stop button is pressed. The appropriate fault indicator lamp lights and common alarm terminal **TB1-4** is powered. (There is no fault lamp for emergency stop.)

    The low oil pressure and high engine temperature shutdowns have 10 second time delays to allow oil pressure and engine temperature to stabilize during startup.

12. To restore operation after a shutdown fault has been serviced, reset latching relay **K6** by pushing the panel **Stop** switch and then the **Reset** switch. The set should run or be ready to run when the panel switch is pushed to **Run** or to **Remote**.

    If the emergency stop switch has been used, the control will have to be reset to restore operation. First pull the emergency stop switch button and then push the panel Stop and Reset switches.

13. The set is stopped manually by pressing the panel **Stop** switch or automatically by a remote controller. (The panel switch must be in the **Remote** position for remote, automatic operation.)

* On older ECM boards (those having cartridge-type fuses):
- If the starter disconnects normally but the panel Run indicator lamp does not light, the DC (K14) starter disconnect circuit is not working.
- If the starter disconnects normally but neither the panel nor the remote Run indicator lamps light, the AC (K10) starter disconnect circuit is not working.

* On newer ECM boards (those having automotive-type fuses):
- If the starter disconnects normally but neither the panel nor the remote Run indicator lamps light, the AC (K10) starter disconnect circuit is not working.
- Both the remote and the panel Run indicator lamps will light even if the DC (K14) starter disconnect circuit is not working. Check the DC voltmeter to determine whether or not the battery charging alternator is working.

4. Troubleshooting

These troubleshooting charts are designed to help you think through generator set problems. To save time troubleshooting, read the entire manual ahead of time to understand the generator set. Try to think through problems. Go over what was done during the last service call. The problem could be as simple as an empty fuel tank, closed fuel shutoff valve, loose wire, blown fuse or tripped circuit breaker.

WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THE ENGINE DOES NOT CRANK

The **Run-Stop-Remote** switch is at **Stop. (**The **Switch-Off** light will be flashing, if provided.)	Push the **Run-Stop-Remote** switch to **Run** or **Remote.**
The **Emergency Stop** switch has been used. (No fault lamp is on.)	Pull the **Emergency Switch** button. To reset the control, push the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset**. Then push the **Run-Stop-Remote** switch to **Run** or **Remote.**
A **Fault Shutdown** is being indicated by one of the red lights on the control panel.	Service the set as necessary. To reset the control, push the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset**. Then push the **Run-Stop-Remote** switch to **Run** or **Remote.**
Cranking voltage is too low to crank the engine.	Clean and tighten or replace the battery cable connectors and cables at the battery and the set.
	Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C).
	If the set is in standby service, install a battery charger.

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THE ENGINE DOES NOT CRANK (CONT.)

Continued from previous page.

Fuse **F1** on the ECM (A11) board has blown.

→ Replace the fuse with one of the same type and amp rating.

→ If fuse **F1** blows again, the wire between ECM terminal **TB1-8** and starter relay **K4** terminal **S** may be loose or damaged, causing a short to ground. Repair as necessary.

→ If fuse **F1** still blows, replace starter relay **K4**.

The wire between ECM terminal **TB1-9** and starter relay **K4** terminal **BAT** is loose, damaged or missing.

→ Check for battery voltage (12 VDC) between ECM terminal **TB1-9** (B+) and the grounding stud (–) on the floor of the control cabinet. Check, clean and tighten the connectors at both ends and replace the wire if it is damaged.

A grounding strap between the control box and the battery negative (**–**) terminal is loose, damaged or missing.

→ Check for electrical continuity (zero ohms) between the the grounding stud on the floor of the control box and the battery negative (**–**) terminal. If there is no electrical continuity, check for loose, damaged or missing grounding straps and repair as necessary.

The **Run-Stop-Remote** switch (S12) or wiring is faulty.

→ Disconnect pin connector **J4** from the ECM board and check for electrical continuity (zero ohms) between switch terminals **2** and **3** when the switch is in the **Run** position and between terminals **1** and **2** when it is in the **Remote** position. Replace the switch if either set of contacts is faulty.

→ If the switch works, check for electrical continuity (zero ohms) between **J4-6** and **J4-7** on the wire harness when the switch is in the **Run** position and between **J4-5** and **J4-6** when the switch is in the **Remote** position. Replace the wire harness if there is no electrical continuity in either position of the switch.

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THE ENGINE DOES NOT CRANK (CONT.)

Continued from previous page.

Possible Cause	Corrective Action
The remote control circuit is faulty.	Push the **Run-Stop-Remote** switch to **Run**. If the engine cranks, find and repair the fault in the remote control circuit.
The ECM is faulty. (Check fuse **F1** again.)	Push the **Run-Stop-Remote** switch to **Run** and check for battery voltage (12 VDC) between ECM terminal **TB1-8** and the grounding stud on the floor of the control box. If there is no voltage when the switch is in the **Run** position, replace the ECM.
The wire between ECM terminal **TB1-8** and starter relay **K4** terminal **S** is loose, damaged or missing.	If the ECM works, push the **Run-Stop-Remote** switch to **Run** and check for battery voltage at starter relay **K4** terminal **S**. If there is no voltage repair the wiring as necessary.
Starter relay **K4** is malfunctioning.	If there is voltage at starter relay **K4** terminal **S**, but not at terminal **SI** ,when the **Run-Stop-Remote** switch is in the **Run** position, replace relay **K4**.
The cable between relay **K4** and the **starter motor** is loose, damaged or missing.	If there is voltage at relay **K4** terminal **SI**, but not at the **starter motor** terminal, when the **Run-Stop-Remote** switch is in the **Run** position, repair the cable as necessary.
The **starter motor** is malfunctioning.	If there is voltage at the starter motor terminal, but the motor does not function, when the **Run-Stop-Remote** switch is in the **Run** position, repair or replace the starter motor according to the engine service manual.

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THE ENGINE CRANKS BUT DOES NOT START

When the **Run-Stop-Remote** switch is in the **Run** position**,** the control will attempt to crank the engine for approximately 75 seconds (including two rest periods) and then the red **OVERCRANK** lamp will light if the engine does not start. If the **OVERCRANK** lamp comes on, reset the control by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset**. Then push the **Run-Stop-Remote** switch to **Run** or **Remote.**

↓

The engine is not getting fuel. (If the set is equipped with the optional low frequency shutdown feature and the red **FAULT 1** or **FAULT 2** lamp is on, the set probably ran out of fuel.)

→ Open any closed shutoff valve in the fuel line supplying the engine.

↓ Fill the main fuel supply tank if the set is gasoline or propane fueled. For natural gas fueled sets, check with the gas utility.

↓

Fuse **F2** on the ECM board (A11) has blown.

→ Replace the fuse with one of the same type and amp rating.

↓ If fuse **F2** blows again, the wire between ECM terminal **TB1-10** and engine block terminal **T26** may be loose or damaged, causing a short to ground. Repair as necessary. (See Figure 3-3 to locate terminal **T26**)

↓ If fuse **F2** still blows, a wire between the ignition coil, fuel solenoid or ignition module and terminal **T26** may be loose or damaged, causing a short to ground. Repair as necessary.

↓

Fuel solenoid **K1** is faulty (does not open).

→ Connect the terminal on fuel solenoid **K1** to the **BAT** terminal on starter relay **K4** with a jumper wire**.** Replace the fuel solenoid if it does not “click” each time power is connected.

↓

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THE ENGINE CRANKS BUT DOES NOT START (CONT.)

Continued from previous page.

The throttle is not opening. (This applies only to sets with electronic governors. There should be visible movement in the throttle linkage when cranking starts.)

→ Connect wires, tighten terminal screws and adjust the governor linkage as necessary according to Section 6, *Governors and Carburetors*. Open and close the throttle by hand to check for binding and repair as necessary. (Opening the throttle will be resisted by a spring inside the actuator, which is normal.)

→ Disconnect the actuator lead connected at governor controller terminal **5** and connect it to the negative (–) terminal of the cranking battery. Then disconnect the lead connected at terminal **4** and touch it to the battery positive (+) terminal. Replace the actuator unit if it does not drive the throttle open when power is connected or return it when power is disconnected.

→ Replace the governor controller if the actuator functions properly.

Low engine temperature is causing too low a cranking speed for starting.

→ Plug in, repair or install engine coolant and engine oil heaters.

→ Replace the engine oil if it is not of the recommended viscosity for the ambient temperature.

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THE ENGINE CRANKS BUT DOES NOT START (CONT.)

Continued from previous page.

Cranking voltage is too low to reach required cranking speed.
→ While cranking the engine, measure voltage directly across the battery terminals and then immediately across the starter motor terminal and the grounding bolt on the block. Cable, terminal or relay contact resistance is too high if the difference is more than 1 volt. Service as necessary.
→ Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C).

The ECM is faulty. (Check fuse **F2** again.)
→ While cranking, check for battery voltage at the terminal **TB1-10** on the ECM. Replace the ECM if there is no voltage at the terminal.

The fuel pump (gasoline-fueled sets) is malfunctioning.
→ Replace or service the fuel pump according to the engine service manual.

The carburetor fuel passages are clogged or the choke needs adjustment (gasoline-fueled sets).
→ Clean and rebuild gasoline carburetors with the appropriate carburetor kit according to the kit instructions. Adjust fuel mixture and choke according to Section *6, Governors and Carburetors.*

The engine ignition system is malfunctioning (electronic module, ignition coil, distributor, spark plugs, high tension spark plug and coil cables and timing).
→ Service according to the engine service manual.

The engine is malfunctioning mechanically.
→ Service according to the engine service manual.

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THE ENGINE RUNS UNTIL FAULT SHUTDOWN

The **OVERSPEED** lamp comes on when the engine shuts down.

→ Reset the ECM by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset** and restart the set, monitoring engine speed. Readjust the cutout speed if it is lower than specified. See Section 3, *Engine Control*.

↓

If the set still shuts down due to overspeed, open and close the throttle by hand to check for binding. Repair and adjust the linkage as necessary according to Section 6, *Governors and Carburetors*. (A spring inside the actuator of an electronic governor will resist opening the throttle, which is normal, and the governor spring of a mechanical governor will resist closing the throttle.)

↓

Mechanical Governor: Readjust the governor according to Section 6, *Governors and Carburetors*. Replace the mechanical governor unit if the set still shuts down due to overspeed.

↓

Electronic Governor: Readjust the governor according to Section 6, *Governors and Carburetors*. If the set still shuts down due to overspeed, re-install the magnetic speed pick-up unit to make sure the clearance with the flywheel gear teeth is correct (Section 6). Replace the speed-pickup unit if output voltage at cranking speed is less than 2.5 VDC as measured at terminals 10 (–) and 11 (+) on the governor controller.

↓

Disconnect the actuator lead connected at governor controller terminal **5** and connect it to the negative (–) terminal of the cranking battery. Then disconnect the lead connected at terminal **4** and touch it to the battery positive (+) terminal. Replace the actuator unit if it does not drive the throttle open when power is connected or return it when power is disconnected.

↓

Replace the governor controller if the set still shuts down due to overspeed.

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⚠WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THE ENGINE RUNS UNTIL FAULT SHUTDOWN (CONT)

Continued from previous page.

The **LOW OIL PRESSURE** lamp comes on when the engine shuts down.

→ Reset the ECM by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset** and fill up with as much engine oil as necessary and repair all oil leaks.

↓ If the set still shuts down due to low oil pressure, disconnect the wire to fuel solenoid **K1** (to keep the engine from starting) and observe oil pressure while cranking the engine. Service the lubricating oil system in accordance with the engine service manual if oil pressure is less than 10 psi. Replace the low oil pressure cutout switch if oil pressure is greater than 10 psi. See Figure 3-3, Section 3, *Engine Control* to locate the switch.

The **HIGH ENGINE TEMPERATURE** lamp comes on when the engine shuts down.

→ Reset the ECM by pushing the **Run-Stop-Remote** switch to **Stop** and the **Reset** switch to **Reset** and fill up with as much engine coolant as necessary and repair all leaks.

↓ If the set still shuts down due to high engine temperature, start the engine and observe coolant temperature as the system heats up. If shutdown occurs before the coolant reaches 200° F (93° C), replace the high engine temperature cutout switch. If coolant temperature exceeds 200° F (93° C), clean and service the entire cooling system as required to restore full cooling capacity. See Figure 3-6, *Engine Sensor Locations,* to locate the switch.

The **FAULT 1** or **FAULT 2** lamp comes on when the engine shuts down.

→ Service as required. (The customer has supplied the system fault indicating switches. By means of selection jumpers, either fault may be chosen to display the warning only. See Section 3, *Engine Control*.)

⚠WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THE ENGINE LACKS POWER OR STABLE SPEED

The governor and carburetor fuel mixture adjustments are incorrect.

→ Adjust the carburetor fuel mixture and the governor according to Section 6, *Governors and Carburetors*.

↓ If the governor cannot be adjusted for full power or stable speed, shut down the set and open and close the throttle by hand to check for binding. Repair and adjust the linkage as necessary. (A spring inside the actuator of an electronic governor will resist opening the throttle, which is normal, and the governor spring of a mechanical governor will resist closing the throttle.)

↓ **Mechanical Governor:** Replace the mechanical governor unit if it cannot be adjusted for full power or stable speed.

↓ **Electronic Governor:** Re-install the magnetic speed pick-up unit to make sure the clearance with the flywheel gear teeth is correct (Section 6). Replace the speed-pickup unit if output voltage at cranking speed is less than 2.5 VDC as measured at terminals **10** (–) and **11** (+) on the governor controller.

↓ Disconnect the actuator lead connected at governor controller terminal **5** and connect it to the negative (–) terminal of the cranking battery. Then disconnect the lead connected at terminal **4** and touch it to the battery positive (+) terminal. Replace the actuator unit if it does not drive the throttle open when power is connected or return it when power is disconnected.

↓ Replace the governor controller if it still cannot be adjusted for full power or stable speed.

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WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THE ENGINE LACKS POWER OR THE SPEED IS UNSTABLE (CONT.)

Continued from previous page.

Gasoline delivery to the set is inadequate. → Check for and replace clogged gasoline fuel lines and filters.

→ Measure the vertical distance between the gasoline fuel pump on the engine and the bottom of the dip tube in the supply tank. Make necessary provisions so that lift does not exceed 6 feet (1.8 metres).

The **Gasoline** fuel is contaminated. → Connect the set to a container of regular gasoline of known quality and run the set under various loads. Replace the contents of the fuel supply tank if there is a noticeable improvement in performance.

Gaseous fuel delivery (vapor withdrawal) to the set is inadequate. → Check the gas supply pressure at the fuel inlet fitting on the skid. Make necessary provisions so that gas supply pressure is at least 10 inches (254 mm) Water Column (WC) when the set is under full load, and not more than 20 inches (508 mm) WC. (The gas supply system must be able to supply this pressure when supplying all other concurrent building loads.)

The **Gaseous fuel** is of insufficient energy content. → Check with the propane supplier or the gas utility to confirm the energy content of the gaseous fuel being used. Propane must have approximately 2500 BTU's per cubic foot and natural gas 1000 BTU's per cubic foot.

The engine air filter element is dirty. → Replace the air filter element.

The carburetor fuel passages (gasoline-fueled sets) are clogged. → Clean and rebuild gasoline carburetors with the appropriate carburetor kit according to the kit instructions. Adjust fuel mixture according to Section 6.

The engine is worn or is misfiring. → Service the engine or ignition system according to the engine service manual.

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ENGINE CONDITION WARNINGS

The **PRE-LOW OIL PRESSURE** lamp comes on while the engine is running. →	Shut down the set if possible or disconnect non-critical loads.(Oil pressure will be less than 30 psi but greater than 25 psi.) Service the engine lubricating system according to the engine service manual.
The **PRE-HIGH ENGINE TEMPERATURE** lamp comes on while the engine is running. →	Shut down the set if possible or disconnect non-critical loads. (Engine temperature will be greater than 205° F [97° C] but less than 215° F [102° C]). Service the engine cooling system to restore full cooling capacity.
The **LOW ENGINE TEMPERATURE** lamp comes on while the set is in standby. →	Plug in, repair or install engine coolant and engine oil heaters.
The **LOW FUEL** lamp comes on. →	Fill the main fuel supply tank with the appropriate grade of fuel. (The customer must supply the fuel level switch to make use of this warning.)
FAULT 1 or **FAULT 2** →	Service as required. (The customer has supplied the system fault indicating switches. By means of selection jumpers, either fault may be chosen to shut down the engine. See See Section 3, *Engine Control*.

⚠WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THERE IS NO OUTPUT VOLTAGE (ENGINE SPEED IS STABLE)

Condition	Corrective Action
The line circuit breaker is **OFF**.	Find out why the circuit breaker was turned **OFF**, make sure it is safe to reconnect power, and then throw the circuit breaker **ON**.
The line circuit breaker has **TRIPPED**.	Shut down the set and service as necessary to clear the short circuit or ground fault that caused tripping, and then **RESET** the circuit breaker and start the set.
The line circuit breaker is faulty.	Shut down the set, make sure the power output lines from the set have been disconnected from all other sources of power, attempt to **RESET** the circuit breaker and throw it **ON** and check for electrical continuity across each line contact. Replace the circuit breaker if there is measurable resistance across any contact.
Field circuit breaker **CB21** has **TRIPPED**.	**RESET** the circuit breaker. If it keeps tripping, troubleshoot according to the chart, *Field Circuit Breaker Keeps Tripping*.
Field circuit breaker **CB21** is faulty.	Shut down the set, attempt to **RESET** the circuit breaker and disconnect either lead. Replace the circuit breaker if there is measurable resistance across the terminals.

Continued on next page.

WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THERE IS NO OUTPUT VOLTAGE (CONT.)

Continued from previous page.

Determine, as follows, whether the fault is in the **VOLTAGE REGULATING** or **GENERATOR** circuits:

1. Throw the line circuit breaker **OFF** and shut down the set.

   CAUTION ***This test involves unregulated excitation of the generator. To prevent damage to the generator due to overcurrent, make sure that all loads have been disconnected and that all faults have been cleared from the power output terminals of the generator.***

2. Open the control panel and disconnect the **X** and the **XX** leads from the voltage regulator. See Figure 2-3 or 2-4, as appropriate.
3. Connect the **XX** lead to the ground stud on the floor of the control box (battery negative [–]).
4. Be prepared to connect the **X** lead to 12 VDC battery positive (+) and to read output voltage across the generator terminals while the set is running. Check polarity again. Polarity must be correct or this test will be inconclusive because the induced and residual magnetic polarities in the exciter stator will be opposed.

   DANGER ***HIGH VOLTAGE. Touching uninsulated high voltage parts inside the control box can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts.***

   For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and wear elbow length insulating gloves intended for hazardous voltages.

5. Start the set and connect the **X** lead to battery positive (+).
6. The generator is probably okay if rated output voltage or higher is obtained and the voltages for all phases are balanced when the exciter is powered by the 12 volt cranking battery. Use the appropriate **VOLTAGE REGULATING FAULT** chart to troubleshoot. (Normal excitation voltage ranges from approximately 10 VDC at no-load to approximately 40 VDC at full-load.)
7. Use the **GENERATOR FAULT** chart to troubleshoot if the output voltages are not balanced or are less than ninety percent of rated output voltage when the exciter is powered by the 12 volt cranking battery. If the voltages are unbalanced, troubleshoot the main stator first. If the voltages are uniformly low, troubleshoot the exciter and field circuits first.

Continued on next page.

⚠WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THERE IS NO OUTPUT VOLTAGE (CONT.)

Continued from previous page.

VOLTAGE REGULATING FAULTS (PMG-EXCITED GENERATORS)

The **PMG** is faulty. → Disconnect leads **P2**, **P3** and **P4** from the voltage regulator. While the set is running, check voltage across lead pairs **P2-P3**, **P3-P4** and **P4-P2**. Service the **PMG** according to Section 5, *Servicing the Generator* if there is less than 150 VAC for 50 Hertz generators or less than 180 VAC for 60 Hertz generators across any pair of leads.

⚠ DANGER ***HIGH VOLTAGE. Touching uninsulated high voltage components and wiring in this compartment can result in severe personal injury or death. Testing must be done with care to avoid touching high voltage parts.***

For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and wear elbow length insulating gloves intended for hazardous voltages.

Voltage Regulator **VR21** is faulty. → Check all connections using the appropriate wiring diagrams in Section 7 and rewire as necessary. Replace the voltage regulator if the wiring is correct and there is no output voltage.

⚠ CAUTION ***Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.***

VOLTAGE REGULATING FAULTS (SELF-EXCITED GENERATORS)

The field has lost its residual magnetism. → Flash the field according to Section 5, *Servicing the Generator.*

Voltage Regulator **VR21** is faulty. → Check all connections against the wiring diagrams on pages 7-3 through 7-6, 7-15 and 7-16 and rewire as necessary. Replace the voltage regulator if the wiring is correct and there is no output voltage.

⚠ CAUTION ***Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.***

Continued on next page.

WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THERE IS NO OUTPUT VOLTAGE (CONT.)

Continued from previous page.

GENERATOR FAULTS

The exciter field winding is faulty (open or shorted). → Shut down the set and check exciter field winding resistance according to Section 5, *Servicing the Generator*. Replace the exciter field assembly if winding resistance does not meet specifications.

The rotating rectifier assembly (diodes **CR1** through **CR6**) is faulty. → Shut down the set and check each diode according to Section 5, *Servicing the Generator*. Service as necessary.

The exciter rotor windings are faulty (open or shorted). → Shut down the set and check exciter winding resistances according to Section 5, *Servicing the Generator*. Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications.

The main rotor winding is faulty (open or shorted). → Shut down the set and check main rotor winding resistance according to Section 5, *Servicing the Generator*. Replace the generator rotor assembly if main rotor winding resistance does not meet specifications.

The stator windings are faulty (open or shorted). → Shut down the set and check stator winding resistances according to Section 5, *Servicing the Generator*. Replace the generator stator assembly if stator winding resistances do not meet specifications.

⚠WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

OUTPUT VOLTAGE IS TOO HIGH OR TOO LOW

Engine speed is too high or too low.
→ Adjust engine speed according to Section 6, *Governors and Carburetors*.
→ If engine speed is unstable, troubleshoot according to the chart, *The Engine Lacks Power or Stable Speed*.

↓

The voltage has been adjusted improperly.
→ Adjust output voltage according to Section 2, *AC Control*.

↓

Improper connections have been made at the generator output terminals.
→ Shut down the set and reconnect according to the appropriate reconnection diagram (Page 7-15 or 7-16).

↓

The rotating rectifier assembly (diodes **CR1** through **CR6**) is faulty.
→ Shut down the set and check each diode according to Section 5, *Servicing the Generator*. Service as necessary.

↓

Voltage Regulator **VR21** is faulty.
→ Replace the voltage regulator.

⚠CAUTION ***Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.***

WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

OUTPUT VOLTAGE IS UNSTABLE

The voltage has been adjusted improperly. → Adjust output voltage according to Section 2, *AC Control*.

↓

The voltage adjusting rheostat on the control panel is faulty (if provided). → Unlock the voltage adjusting screw on the front of the control panel and disconnect either lead from the rheostat. Measure resistance between terminals **1** and **2** while turning the adjusting screw fully one way and then the other. Replace the rheostat if it is open at any point, or if resistance does not vary smoothly from zero to approximately 100,000 ohms.

↓

Voltage Regulator **VR21** is faulty. → Replace the voltage regulator.

CAUTION ***Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.***

⚠WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THE FIELD CIRCUIT BREAKER KEEPS TRIPPING

The rotating rectifier assembly (diodes **CR1** through **CR6**) is faulty. → Shut down the set and check each diode according to Section 5, *Servicing the Generator*. Service as necessary.

↓

The exciter field winding is faulty (open or shorted). → Shut down the set and check exciter field winding resistance according to Section 5, *Servicing the Generator*. Replace the exciter field assembly if winding resistance does not meet specifications.

↓

The exciter rotor windings are faulty (open or shorted). → Shut down the set and check exciter winding resistances according to Section 5, *Servicing the Generator*. Replace the generator rotor assembly if exciter rotor winding resistances do not meet specifications.

↓

The main rotor winding is faulty (open or shorted). → Shut down the set and check main rotor winding resistance according to Section 5, *Servicing the Generator*. Replace the generator rotor assembly if main rotor winding resistance does not meet specifications.

↓

The stator windings are faulty (open or shorted). → Shut down the set and check stator winding resistances according to Section 5, *Servicing the Generator*. Replace the generator stator assembly if stator winding resistances do not meet specifications.

↓

Voltage Regulator **VR21** is faulty. → Replace the voltage regulator.

⚠CAUTION ***Replacing the voltage regulator before servicing other faults can lead to damage to the new voltage regulator.***

WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about fuel, electrical and machinery hazards. Read the safety precautions inside the front cover and carefully observe all instructions and precautions in this manual.***

THE PHASE CURRENTS ARE UNBALANCED

The connected loads are distributed unevenly among the phases. →	Shut down the set and redistribute the loads so that there is a difference of less than 10 percent between phases.
Improper connections have been made at the generator output terminals. →	Shut down the set and reconnect according to the appropriate reconnection diagram in Section 7.
The stator windings are faulty (open or shorted). →	Shut down the set and check stator winding resistances according to Section 5, *Servicing the Generator*. Replace the generator stator assembly if stator winding resistances do not meet specifications.
A load has a ground fault or short circuit. →	Service the faulty equipment as necessary.

5. Servicing the Generator

TESTING THE GENERATOR

These tests can be performed without removing the generator. Before starting tests, disconnect the starting battery cables (negative [-] first) to make sure the engine will not start while performing these tests.

CAUTION ***Always disconnect a battery charger from its AC source before disconnecting the battery cables. Otherwise, disconnecting the cables can result in voltage spikes high enough to damage the DC control circuits of the set.***

WARNING ***Accidental starting of the generator set while working on it can cause severe personal injury or death. Prevent accidental starting by disconnecting the starting battery cables (negative [–] first).***

Make certain battery area has been well-ventilated before servicing battery. Arcing can ignite explosive hydrogen gas given off by batteries, causing severe personal injury. Arcing can occur when cable is removed or re-attached, or when negative (–) battery cable is connected and a tool used to connect or disconnect positive (+) battery cable touches frame or other grounded metal part of the set. Always remove negative (–) cable first, and reconnect it last. Make certain hydrogen from battery, engine fuel, and other explosive fumes are fully dissipated. This is especially important if battery has been connected to battery charger.

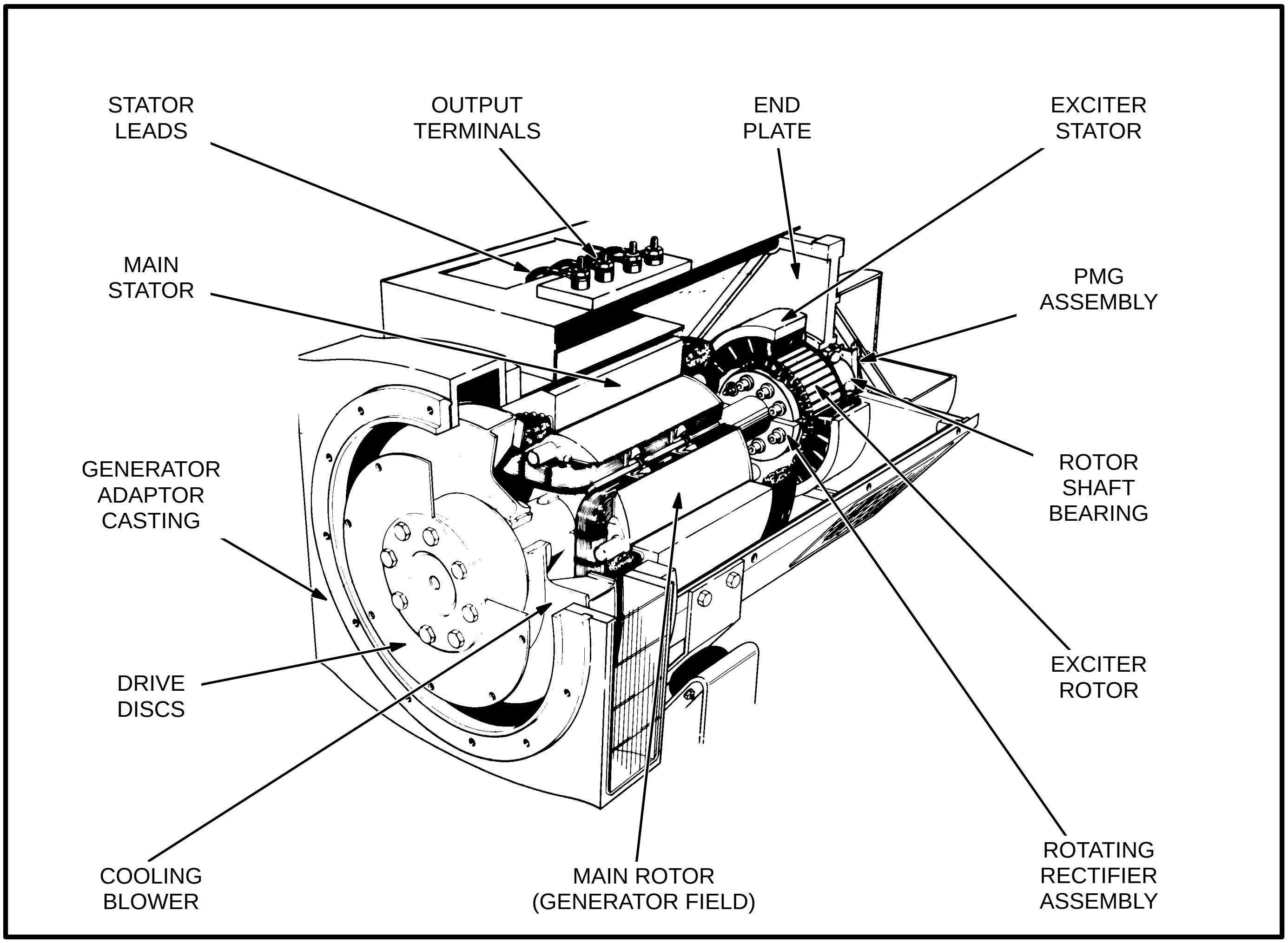


FIGURE 5-1. GENERATOR

Exciter Stator

Testing Winding Resistance: Measure winding resistance with a Wheatstone bridge or digital ohmmeter. Replace the stator if winding resistance is not as specified by Table 5-1.

Testing Winding Insulation Resistance: Disconnect the exciter stator leads from terminals **X** and **XX** on the auxiliary terminal board in the generator output box. Using an ohmmeter, measure resistance between either lead and the stator laminations. Replace the stator if insulation resistance is less than 1 megohm (1,000,000 ohms)

Flashing the Field (Self-Excited Generators Only): If necessary, flash the exciter field before or after installation. Apply 110 to 220 VAC for one to two seconds to the **X** and **XX** leads of the exciter stator. **The generator must be shut down, the AVR disconnected, a diode used to establish correct polarity and a 3 amp fuse to prevent over-excitation.** See the diagram.

Alternatively, while the set is running and disconnected from all loads, apply a 12 VDC battery for one to two seconds as shown in the diagram. **Polarity must be correct: + to X, – to XX**.

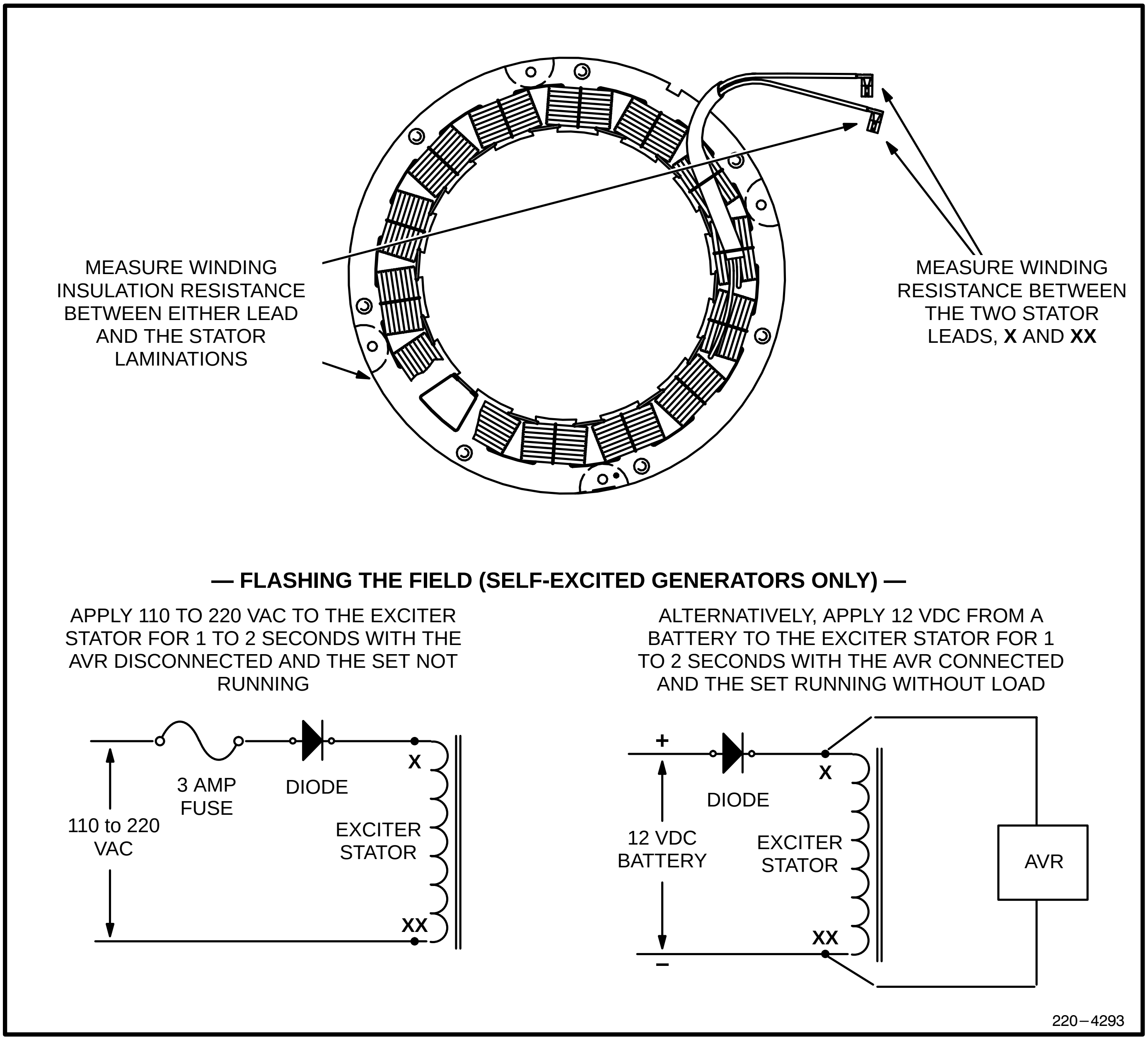


FIGURE 5-2. TESTING AND FLASHING THE EXCITER STATOR

Exciter Rectifier Bridge (Rotating Rectifier Assembly)

The exciter rectifier bridge is mounted on the exciter rotor, inboard, facing the main rotor. It consists of a positive plate and a negative plate, split diametrically. Each carries three diodes, three terminal posts for connecting exciter rotor leads to the diode pigtails and a terminal for the main rotor (generator field) lead. A surge suppresser is connected across the two plates to prevent transient voltages that could damage the diodes.

Testing Diodes: Disconnect the diode pigtails from the terminal posts. Using an ohmmeter, measure electrical resistance between each diode pigtail and the plate on which the diode is mounted. Reverse the meter test probes and repeat the tests. The electrical resistance across each diode should be high in one direction and low in the other. If the resistance is high or low in both directions, replace the diode.

Replacing Diodes: Make sure the replacement diode is of the correct polarity. Disconnect the pigtail from the terminal post and unscrew the old diode. Apply heat-sink compound under the head of the diode. Make sure the compound does not get on the threads. Torque the diodes to 36 to 42 in-lbs (4 to 4.8 Nm) and the pigtail terminals to 24 in-lbs (2.7 Nm) when reassembling.

Surge Suppresser Testing and Replacement: Remove the suppresser. Replace the suppresser if it appears to have overheated or if ohmmeter readings indicate less than infinite resistance (end of scale) in both directions. Torque the terminals to 24 in-lbs (2.7 Nm) when reassembling.

CAUTION ***Layers of dust can cause diodes to overheat and fail. Brush dust off regularly.***

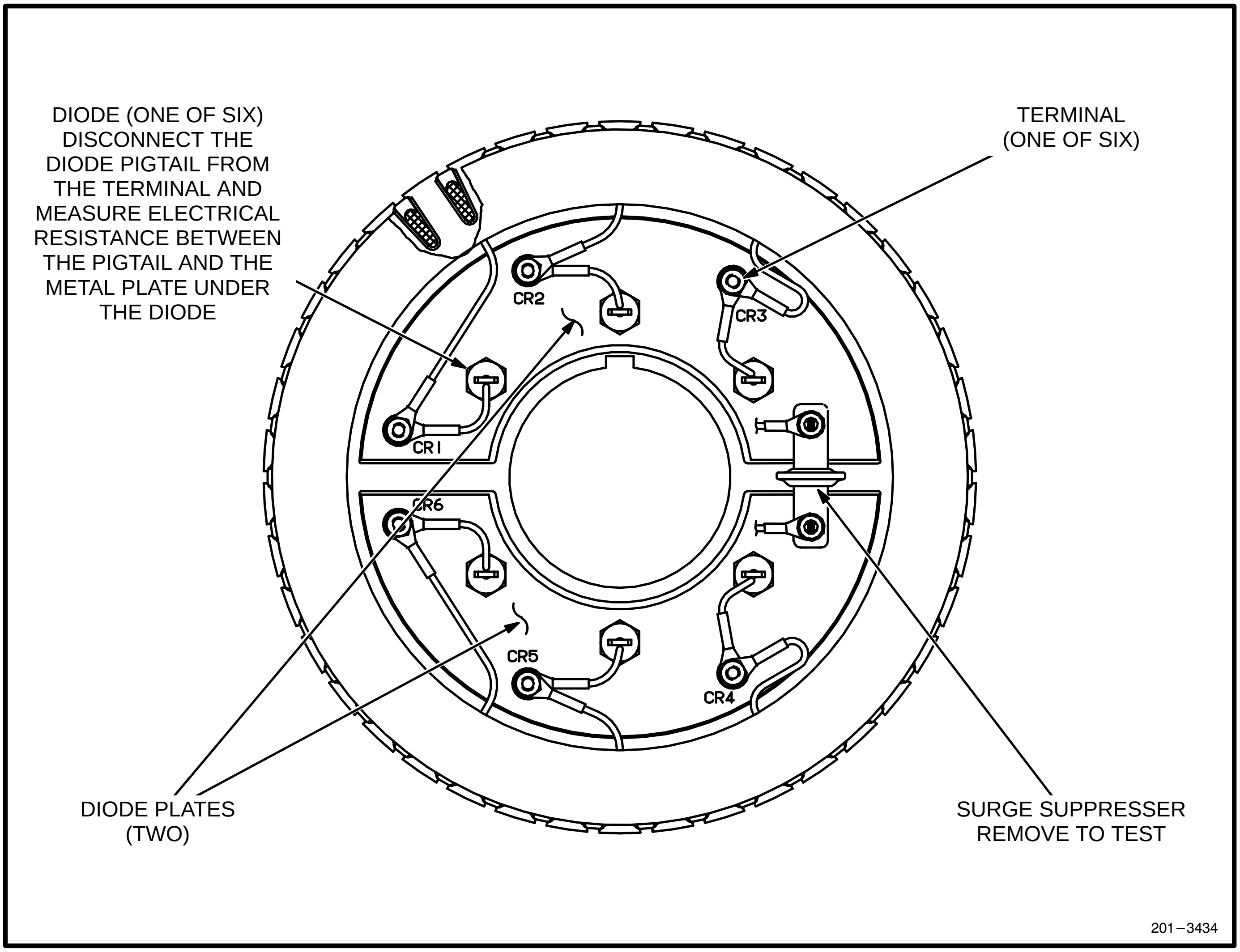


FIGURE 5-3. TESTING THE ROTATING RECTIFIER ASSEMBLY

Exciter Rotor

Testing Winding Resistance: Disconnect the six rotor winding leads from the terminal posts on the rectifier assembly. With a Wheatstone bridge, measure electrical resistance across each pair of rotor windings: **U** (CR1 or CR4) and **V** (CR2 or CR5), **V** (CR2 or CR5) and **W** (CR3 or CR6), **W** (CR3 or CR6) and **U** (CR1 or CR4). See the winding schematic. Replace the exciter rotor assembly if the resistance of any winding is not as specified in Table 5-1.

Testing Winding Insulation Resistance: Using a megger (voltage set at 600 VAC or less), measure the resistance between any rotor winding lead or the terminal to which it is connected and the rotor laminations. Replace the whole rotor shaft assembly if insulation resistance is less than 1 megohm.

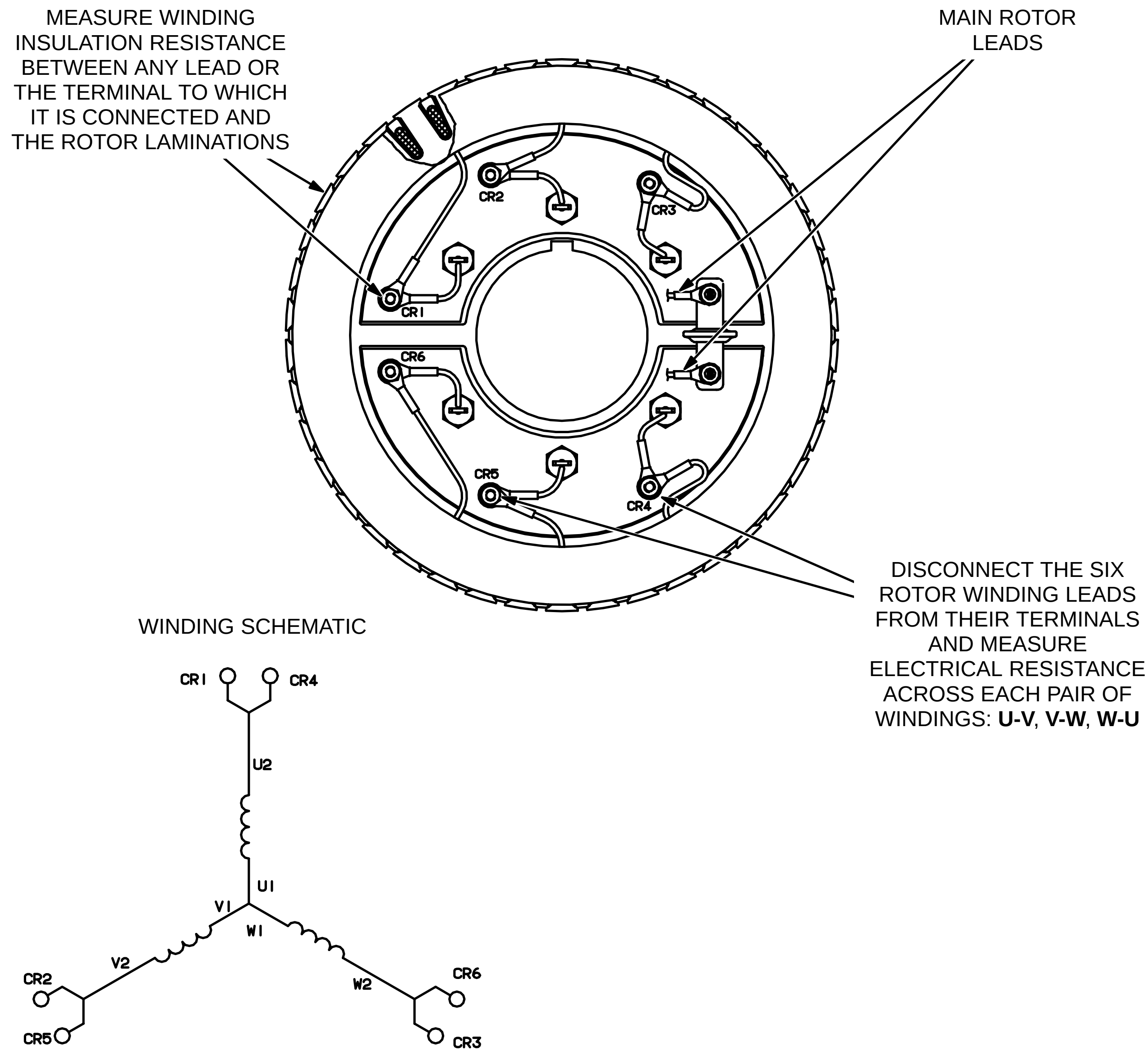


FIGURE 5-4. TESTING THE EXCITER ROTOR

Main Rotor (Generator Field)

Testing Winding Resistance: Disconnect the two leads of the main rotor from the terminals on the rotating rectifier assembly. See Figure 5-4. Measure electrical resistance between the two leads with a Wheatstone bridge or digital ohmmeter. Replace the rotor if the resistance is not as specified in Table 5-1. Connect the rotor leads and torque the terminals to 24 in-lbs (2.7 Nm) when reassembling.

Testing Winding Insulation Resistance: Using a megger (voltage set at 600 VAC or less), measure the resistance between either lead of the main rotor windings, or the terminal to which it is connected, and the main rotor laminations. Replace the rotor if insulation resistance is less than 1 megohm.

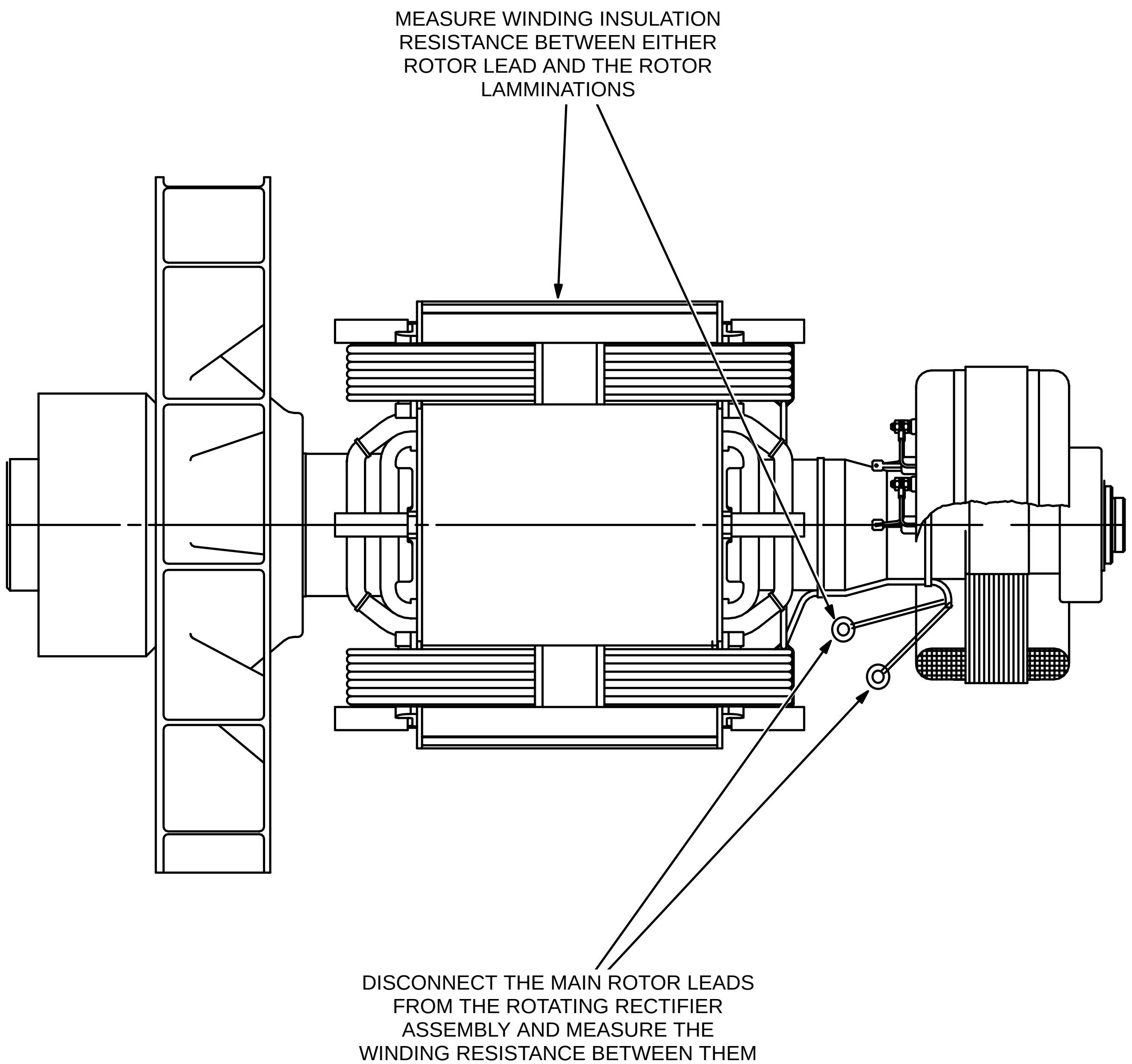


FIGURE 5-5. TESTING THE MAIN ROTOR

Main Stator

Testing Winding Resistance: Measure electrical resistance across each pair of stator leads (U1-U2, U5-U6, VI-V2, V5-V6, W1-W2 and W5-W6) with a Wheatstone bridge or ohmmeter having at least 0.001 ohm precision. Replace the stator if the resistance of any winding is not as specified in Table 5-1.

Alternatively, winding resistance can be measured line-to-line at the generator terminals (U-V, V-W, W-U) on "star" connected generators. On a 600 volt generator, line-to-line resistance should be twice the table value (two winding elements in series). On a "series star" connected generator, line-to-line resistance should be four times the table value (four winding elements in series). On a "parallel star" connected generator, line-to-line resistance should be the same as the table value (two sets of two winding elements in series).

Testing Winding Insulation Resistance: Disconnect all stator leads and winding taps from their respective terminals and make sure the ends do not touch the generator frame.

Testing For Grounds: Using a megger (voltage set at 600 VAC or less) measure electrical resistance between any stator lead and the stator laminations. Replace the stator if insulation resistance is less than 1 megohm.

Testing For Shorts: Using a megger (voltage set at 600 VAC or less) measure electrical resistance between each winding, for example U1/U2 to U5/U6, U1/U2 to V1/V2, etc. Replace the stator if insulation resistance is less than 1 megohm.

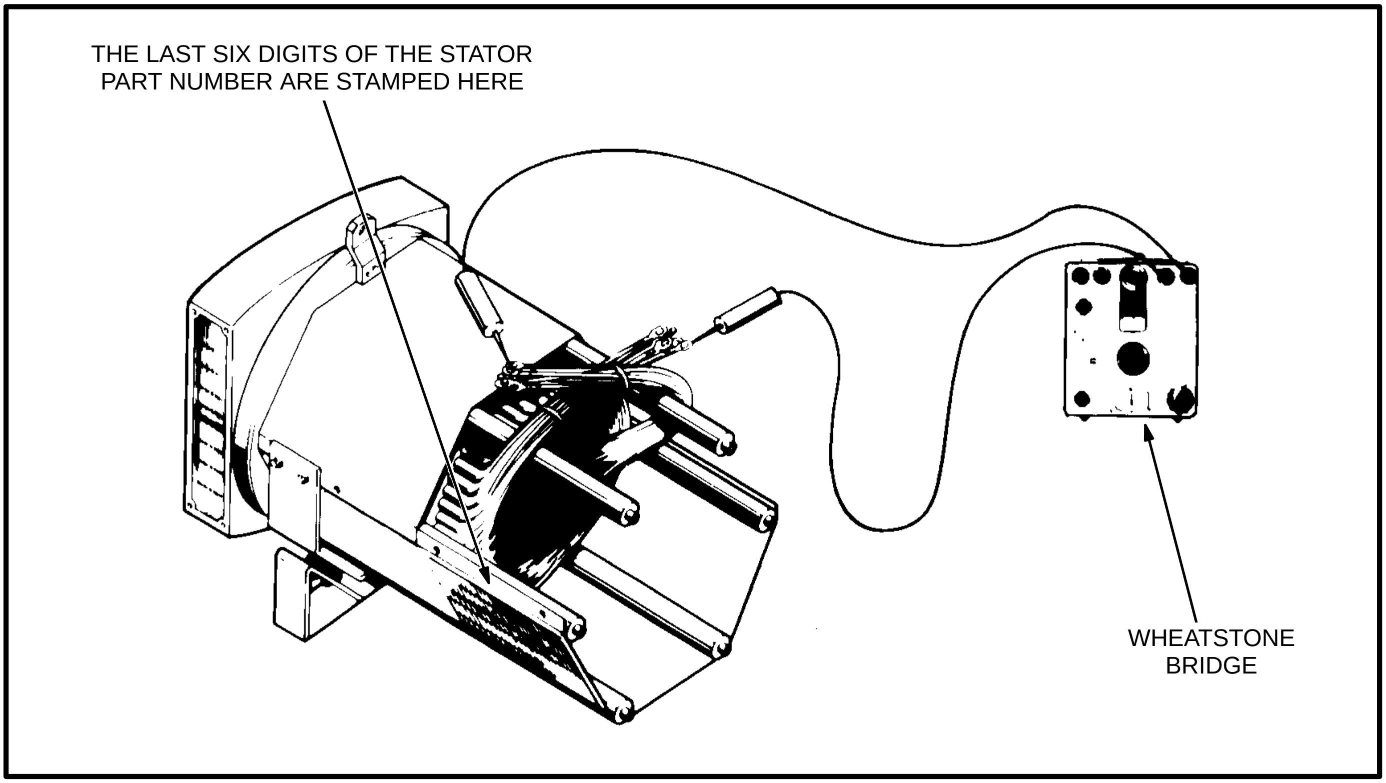


FIGURE 5-6. TESTING THE GENERATOR STATOR

TABLE 5-1. GENERATOR WINDING RESISTANCES*

MAIN STATOR PART NUMBER**	MAIN STATOR (OHMS)	MAIN ROTOR (OHMS)	EXCITER STATOR (OHMS)	EXCITER ROTOR (OHMS)
220-4289–31	0.170	0.57	20.3	0.167
220-4289-32	0.129	0.64	20.3	0.167
220-4289-33	0.110	0.67	19.5	0.180
220-4289-34	0.069	0.80	19.5	0.180
220-4289–35	0.055	0.93	19.5	0.180
220-4298-31	0.062	1.11	19.5	0.180
220-4298-32	0.047	1.20	19.5	0.180
220-4298-33	0.033	1.31	19.5	0.210
220-4298-34	0.025	1.50	19.5	0.210
220-4298-35	0.022	1.66	19.5	0.210
22O-4298-36	0.016	1.80	19.5	0.210
220-4289–31	0.170	0.57	20.3	0.167
220-4289-32	0.129	0.64	20.3	0.167
220-4289-33	0.110	0.67	19.5	0.180
220-4289-34	0.069	0.80	19.5	0.180
220-4289–35	0.055	0.93	19.5	0.180
220-4298-31	0.062	1.11	19.5	0.180
220-4298-32	0.047	1.20	19.5	0.180
220-4298-33	0.033	1.31	19.5	0.210
220-4298-34	0.025	1.50	19.5	0.210
220-4298-35	0.022	1.66	19.5	0.210
22O-4298-36	0.016	1.80	19.5	0.210

* - These values are approximate, plus or minus 10 percent at 68° F (20° C).
** - See Figure 5-6 for the location of the stator part number.

REMOVING AND DISASSEMBLING THE GENERATOR

The generator is heavy. You will need an assistant and a hoist of sufficient capacity to remove and service the generator.

WARNING ***Accidentally dropping the generator can damage it and cause severe personal injury and death. The hoist, straps and chains must have sufficient capacity and be attached properly so that the load cannot shift.***

Before starting, disconnect the starting battery cables (negative (-) first) to make sure the set will not start while working on it.

WARNING ***Accidental starting of the generator set while working on it can cause severe injury or death. Prevent accidental starting by disconnecting the starting battery cables (negative (-) first).***

Always remove the negative (-) cable first, and reconnect it last, to prevent arcing if a tool accidentally touches the frame or other grounded metal part while removing the positive (+) battery cable. Arcing can ignite the explosive hydrogen gas given off by the batteries, causing severe injury.

Removing The Generator Output Box

8. Disconnect the line cables and conduit. For reconnections later, make sure each cable is clearly marked to indicate the correct terminal.
9. Disconnect the remote control wiring and conduit. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.
10. Disconnect all engine wiring harness connections in the generator control and output boxes. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.
11. Disconnect all generator control leads (winding taps) from connections in the output box. For reconnections later, make sure each wire is clearly marked to indicate the correct terminal.
12. If the set has a mounted line circuit breaker, disconnect the cables to the circuit breaker. For reconnections later, make sure each cable is clearly marked to indicate the correct terminal.
13. Attach a hoist to the generator output box, loosen the mounting bolts on the sides of the generator and remove the box.

Withdrawing The Generator From The Set

1. The rotor will be carried inside the stator when the generator is withdrawn from the engine. Bar the engine until one of the four poles of the rotor points straight down so that the rotor will rest on the face of the pole when the generator is withdrawn.

   CAUTION ***The rotor can be damaged if it rests on the edges of the winding slot between two poles.***

2. Attach lifting eyes and a hoist of sufficient capacity (Figure 5-7).
3. Take up hoist slack and remove the two through bolts securing the generator to the rubber isolation mounts.
4. Raise the generator end approximately one inch (12 mm) and securely block the engine under the flywheel housing. Lower the generator slightly so that the blocks carry most of the weight.
5. Remove the bolts securing the generator drive discs to the flywheel.
6. Loosen all the bolts securing the generator adapter casting to the flywheel housing. Adjust the hoist to carry the full weight of the generator, remove the bolts and pull the generator away.

   CAUTION ***Never withdraw the generator leaving the rotor to hang by the drive discs. The weight of the rotor will damage the drive discs.***

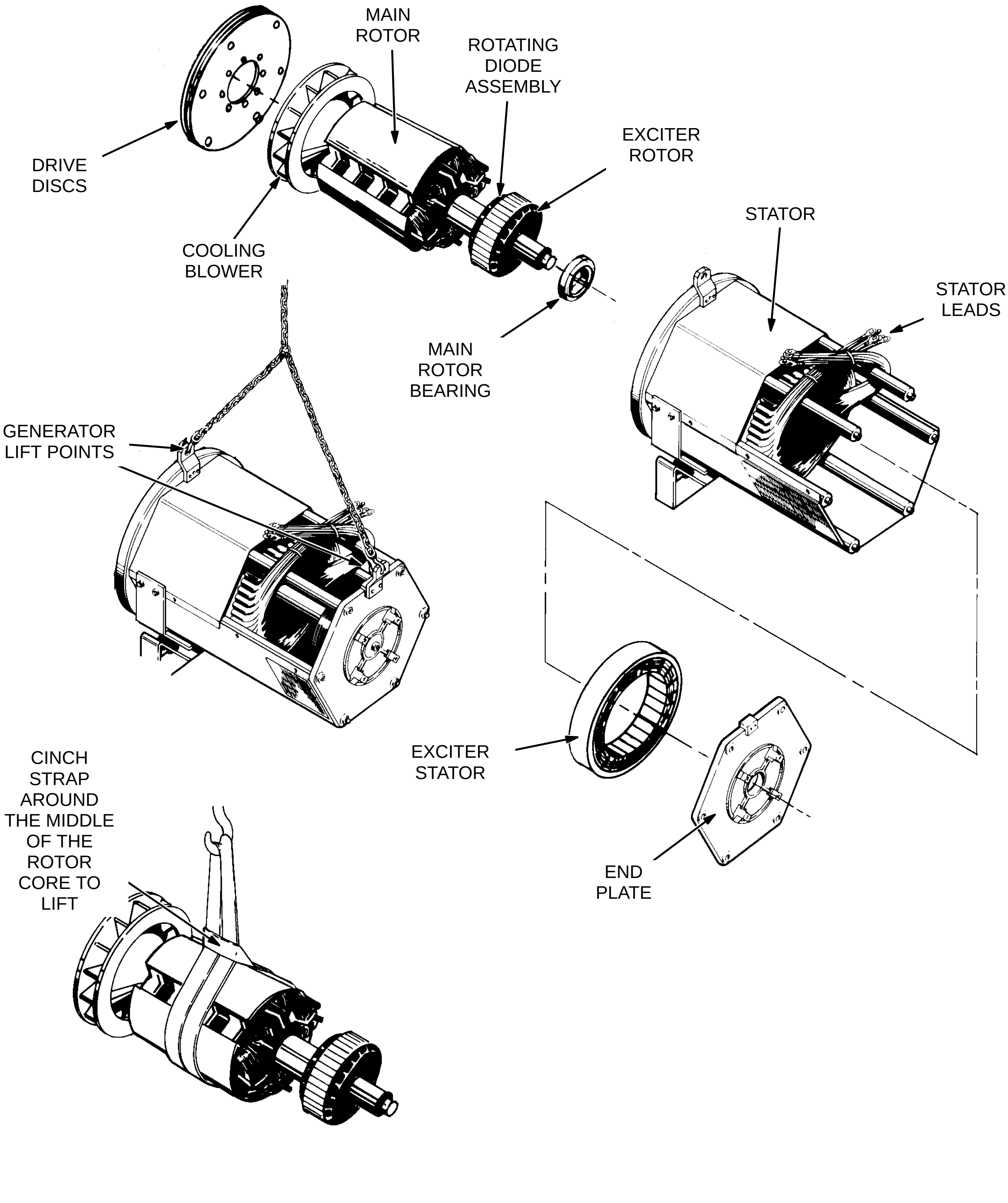


FIGURE 5-7. GENERATOR ASSEMBLY

Withdrawing the Rotor From the Generator

1. Remove the generator adaptor casting on the drive disc end and the end plate on the bearing end.
2. Using a hoist of sufficient capacity, cinch a lifting strap on the drive end of the rotor. Lift the bearing end of the rotor by hand and push it towards the drive end of the generator until half the width of the rotor core protrudes from the stator. Release the weight of the rotor and recinch the lifting strap around the middle of the rotor core. Withdraw the rotor until it is free of the stator, guiding it by hand on both ends to prevent contact with the stator windings
3. Rest the rotor in a cradle, solidly supporting it on two pole faces—not on the drive discs, blower or exciter.
4. Remove the retaining clip if the rotor shaft bearing is to be removed.

REASSEMBLING THE GENERATOR

Reassembling is the reverse of disassembling. Note the following.

1. Apply force to the inner race of the rotor bearing when pressing it onto the shaft, otherwise, it will be damaged. Be sure to secure the retaining clip.
2. The drive disc-to-rotor bolts should be torqued to 190 ft-lbs (257 Nm).
3. The drive disc-to-flywheel bolts should be torqued to 50 ft-lbs (67 Nm).
4. The exciter stator mounting screws should be torqued to 7 ft-lbs (10 Nm).
5. The generator end plate mounting bolts should be torqued to 25 ft-lbs (34 Nm).
6. Make sure the rubber O-ring is in place in the bearing bore in the generator endplate.
7. The generator mounting bracket bolts should be torqued to 65 ft-lbs (88 Nm) if M12 or 35 ft-lbs (47 Nm) if M10.
8. The generator-to-adaptor bolts should be torqued to 40 ft-lbs (55 Nm).
9. The adaptor-to-engine bolts should be torqued to 35 ft-lbs (48 Nm).
10. Reconnect the generator as required. See Pages 7-15 through 7-18.

SERVICING THE PMG

The following is applicable if the generator is equipped with a PMG (permanent magnet) exciter.

Testing

1. Disconnect leads **P2**, **P3** and **P4** from the voltage regulator.
2. Start the engine at the set and let the speed stabilize.

   ⚠ DANGER ***HIGH VOLTAGE. Touching uninsulated high voltage parts inside the control and power output boxes can result in severe personal injury or death. Measurements and adjustments must be done with care to avoid touching high voltage parts.***

   For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and wear elbow length insulating gloves intended for hazardous voltages..

3. Measure voltage across lead pairs **P2-P3**, **P3-P4** and **P4-P2**. Voltage should be at least 150 VAC for 50 Hz sets and at least 180 VAC for 60 Hz sets, and should be approximately the same for each set of leads. If the voltages are low or uneven, check all the leads and connections between the voltage regulator and the PMG and repair as necessary before disassembling the PMG. Note the connections at the auxiliary terminal board in the power output box. See Figure 2-3.
4. Stop the set and measure electrical resistance across lead pairs **P2-P3**, **P3-P4** and **P4-P2** with a Wheatstone bridge or digital ohmmeter. Each winding should have a resistance of approximately 4.4 ohms.

Disassembling the PMG

1. Disconnect the starting battery cables (negative (-) first) to make sure the set will not start while working on it.

   CAUTION ***Always disconnect a battery charger from its AC source before disconnecting the battery cables. Otherwise, disconnecting the cables can result in voltage spikes high enough to damage the DC control circuits of the set.***

   WARNING ***Accidental starting of the generator set while working on it can cause severe personal injury or death. Prevent accidental starting by disconnecting the starting battery cables (negative [–] first).***

   Make certain battery area has been well-ventilated before servicing battery. Arcing can ignite explosive hydrogen gas given off by batteries, causing severe personal injury. Arcing can occur when cable is removed or re-attached, or when negative (–) battery cable is connected and a tool used to connect or disconnect positive (+) battery cable touches frame or other grounded metal part of the set.

   Always remove negative (–) cable first, and reconnect it last. Make certain hydrogen from battery, engine fuel, and other explosive fumes are fully dissipated. This is especially important if battery has been connected to battery charger.

2. Remove the PMG cover (Figure 5-8) and disconnect the leads at the connector.
3. Remove the bolts and clamps that secure the PMG stator to the generator frame and carefully pull away the stator.

   The rotor is magnetic and will attract the stator. Hold the stator firmly so that the windings are not damaged by striking the stator support lugs.

4. Remove the rotor center bolt and pull away the rotor. The rotor is magnetic and will attract iron filings. Put it in a clean plastic bag until it is remounted. Do not take it apart or it will lose its magnetism. Also, if the dowel pin in the end of the shaft is loose, stow it in a safe place until it is time to reassemble the PMG.

Reassembling the PMG

CAUTION ***The rotor is magnetic and will attract the stator. When installing the stator, hold the stator firmly and keep fingers out of the way to prevent pinching of fingers between stator and generator assembly.***

Reassembling is the reverse of disassembling. Torque the rotor center bolt to 40 ft-lbs (54 Nm). The stator leads must be at 12 o'clock.

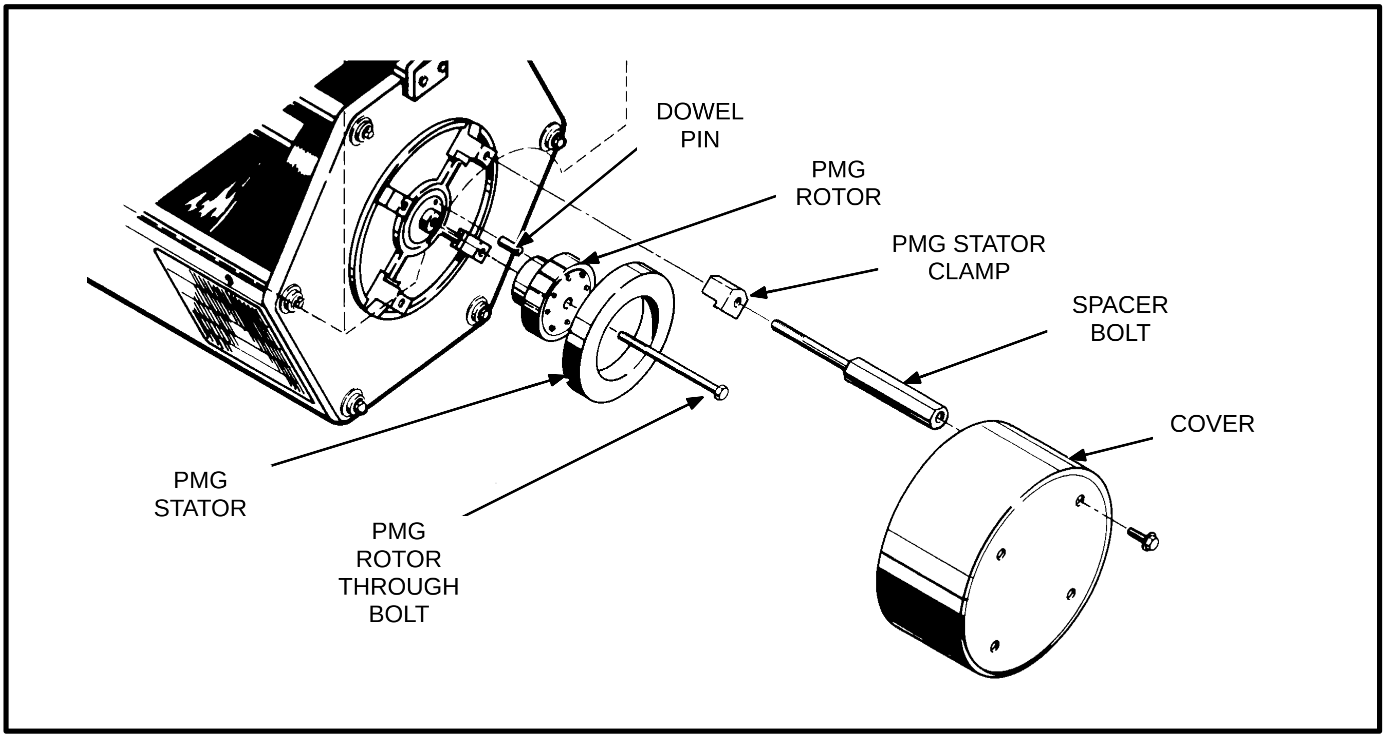


FIGURE 5-8. PMG ASSEMBLY

6. Governors and Carburetors

MECHANICAL GOVERNOR (Prior to Spec F)

Governor Adjustment (Prior to Spec F)

Output frequency (50 Hz or 60Hz) can be adjusted by turning the governor speed adjustment screw (Figure 6-1). Make the frequency adjustment under full-load after the engine has been warmed up under at least 1/4 load. If the governor hunts, or if droop is excessive (more than 3 Hz for 60 Hz sets or 2.5 Hz for 50 Hz sets), adjust the length of the droop adjusting screw accordingly.

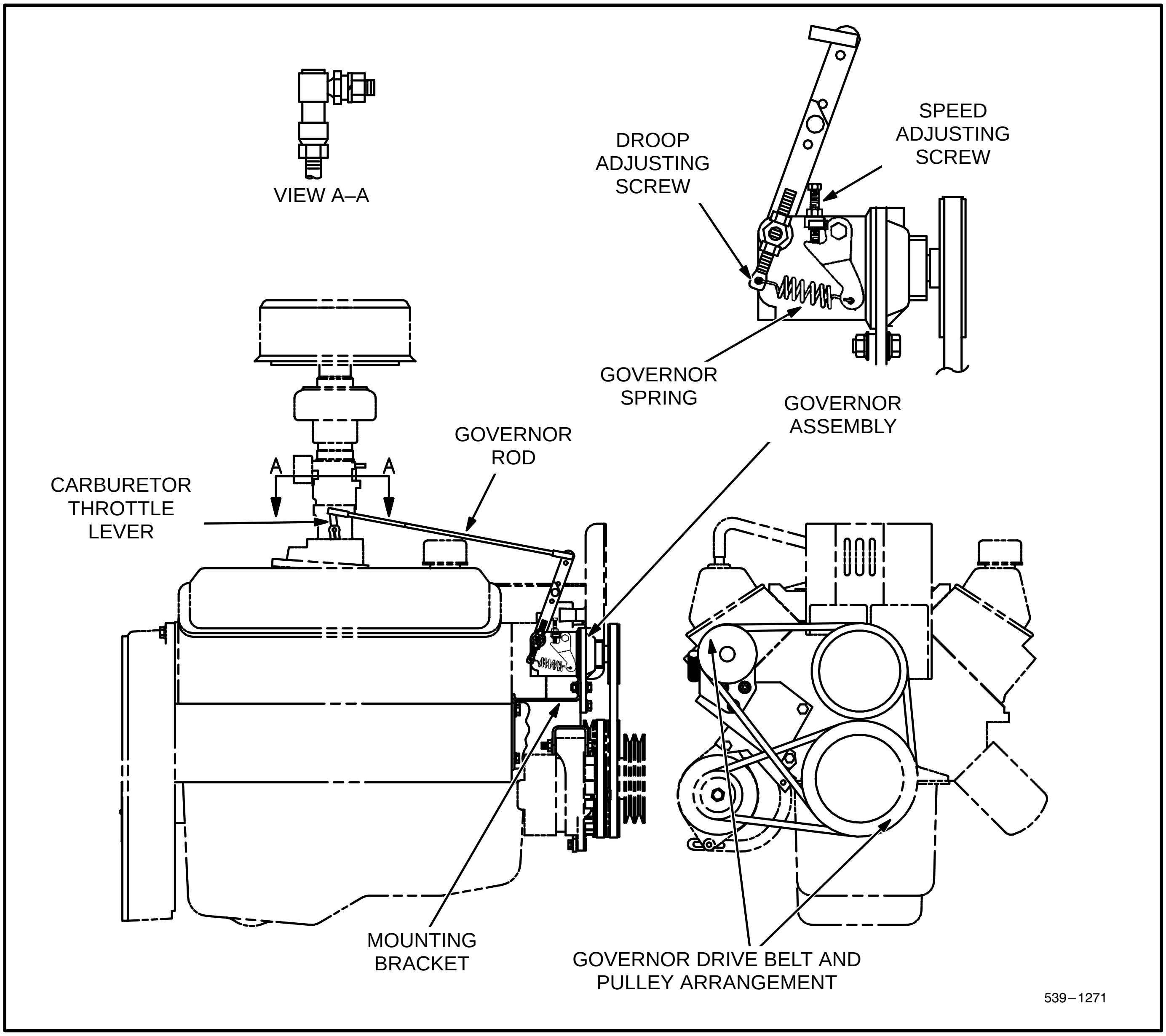


FIGURE 6-1. MECHANICAL GOVERNOR

ELECTRONIC GOVERNOR (Prior to Spec F)

Electric Governor Adjustment (Prior to Spec F)

If necessary, adjust the linkage, wire the controller and install the magnetic speed pickup unit as instructed in this section before adjusting the governor controller. Also make sure that the governor linkage does not bind or have excessive play in it.

1. Warm up the set under at least 1/4 load until the engine is up to its normal operating temperature.
2. Disconnect the load and turn the **Droop** (Figure 6-2) potentiometer to zero.
3. Turn the **Speed** potentiometer to obtain the specified output frequency (50 Hz or 60 Hz).
4. Turn the **Gain** potentiometer clockwise until the governor begins to hunt. Turn it back until there is no audible hunting.
5. Adjust the **D** potentiometer (if provided) the same way as the **Gain** potentiometer (Step 4).
6. Manually push the throttle to the minimum speed position and hold it there until the engine reaches minimum speed. Release the throttle and observe the overshoot on a frequency meter. Adjust the **I** potentiometer counterclockwise slightly to decrease overshoot. Some overshoot is acceptable.
7. Connect 1/4 load and readjust the **Gain** potentiometer (Step 4).
8. Connect rated-load in one step while the set is running. Shut down the set if it cannot pick up the load. Lengthen the governor rod by half turns and repeat the test until the set is able to pick up rated-load in one step. For B-Series engines, shorten the governor rod by half turns and repeat the test until the set is able to pick up rated-load in one step. Back off the governor full speed stop screw if necessary.
9. Check for stability (no audible hunting) under a range of loads from no-load to full-load.
10. Stop the set and wait for 30 seconds for the turbo to coast down. Restart the set and check for speed overshoot. If overspeed shutdown occurs, check for linkage binding and repair as necessary.
11. Set the governor rod locknuts, if necessary, and check again for binding in the linkage.

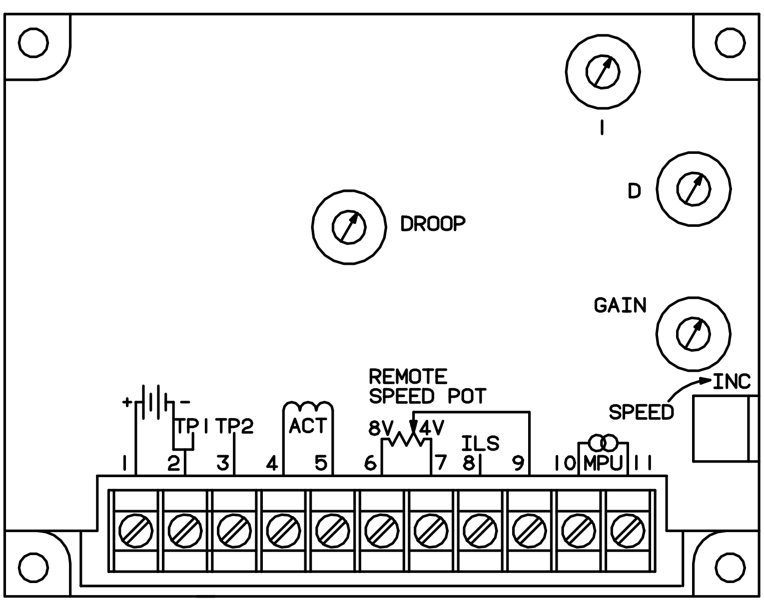


FIGURE 6-2. GOVERNOR CONTROLLER TERMINALS AND ADJUSTING POTENTIOMETERS

151-0715

Wiring (Prior to Spec F)

Wire the governor according to Figure 6-3. Be sure to twist together the power supply leads from B+ and B–.

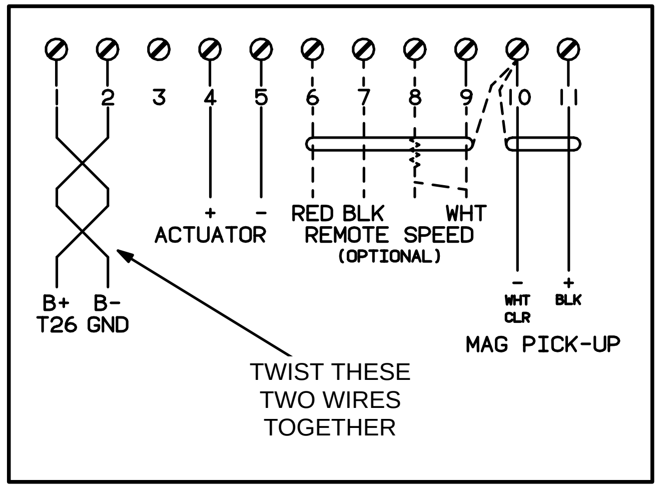


FIGURE 6-3. WIRING THE GOVERNOR

Magnetic Speed-Pickup Unit (Prior to Spec F)

To install the magnetic speed-pickup unit, bar the engine until a gear tooth on the flywheel lines up in the center of the mounting hole in the flywheel housing. Thread the unit in gently by hand until it just touches the gear tooth. Back it out one quarter turn and set the lock nut.

Linkage Adjustment (Prior to Spec F)

Assemble the linkage as shown in Figure 6-4 and adjust the length of the governor rod as necessary.

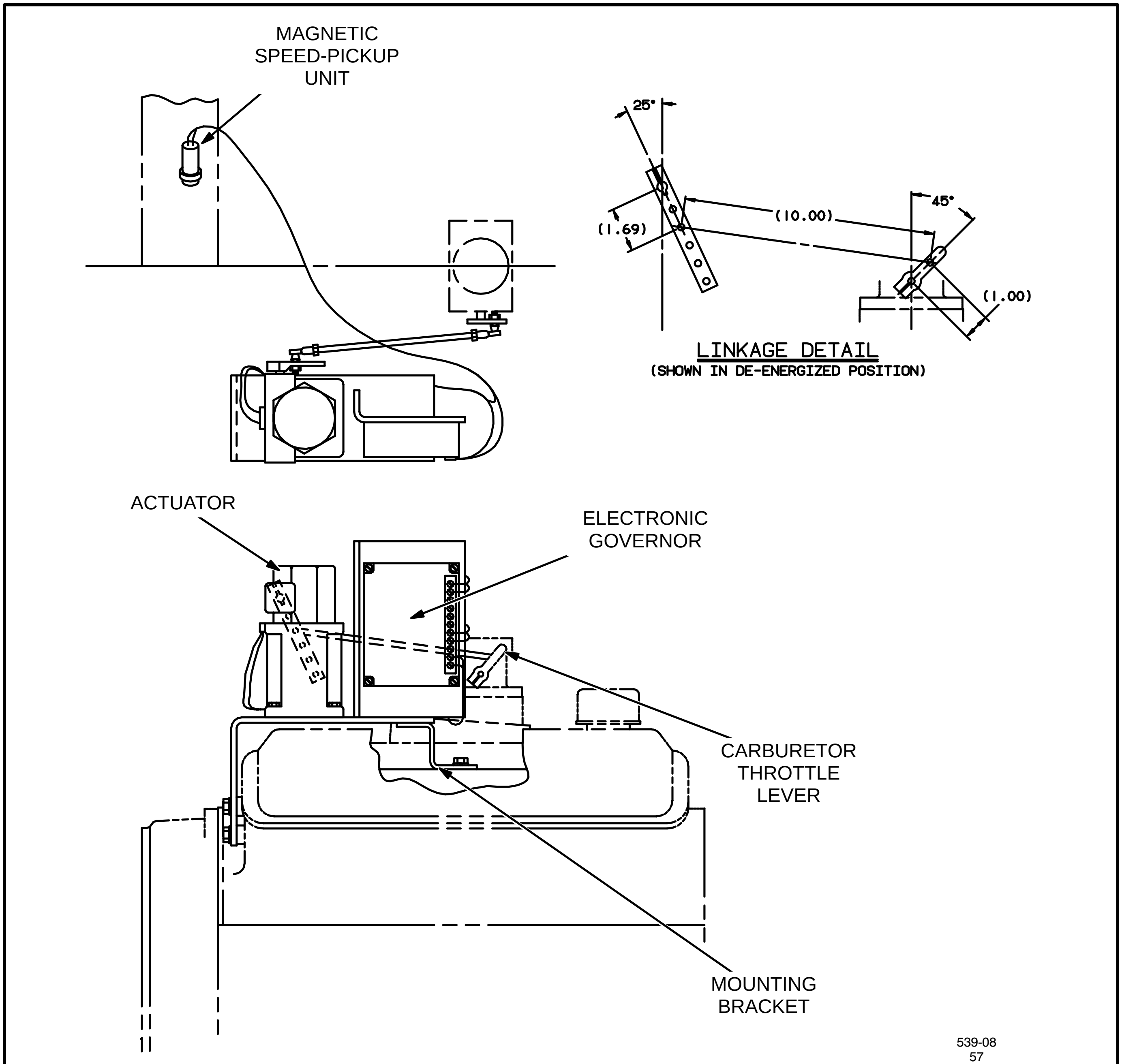


FIGURE 6-4. ELECTRONIC GOVERNOR COMPONENTS

ELECTRIC GOVERNOR (Begin Spec F)

Electric Governor Adjustment (Begin Spec F)

If necessary, adjust the gas mixture, the governor linkage and the magnetic speed pickup unit as instructed in this section before adjusting the governor controller. Make sure that the governor assembly is securely mounted. Also make sure that the governor linkage does not bind or have excessive play in it.

1. Check the dip switch settings (Figure 6-5) to make sure they are set properly, as follows:

	SW1	SW2	SW3	SW4
50 Hz	ON	OFF	OFF	OFF
60 Hz	ON	OFF	OFF	ON

2. Start the set, let the engine warm up under a partial load (at least 1/4 rated load) and then disconnect all loads. (If the governor has been replaced, adjust the gain 1 and stability 1 pots to their center settings.)

3. Adjust the gain 1 pot until the engine is stable and responsive to governor control. (Adjust the gain 1 pot counterclockwise to eliminate hunting.) Bump the throttle lever a couple of times to check for hunting. The unit should respond quickly but should not hunt.

4. Apply full load to the genset and adjust the stability 1 pot to minimize overshoot. (Adjust the stability 1 pot clockwise to increase stability.) Check stability under a range of loads; from no-load to full-load.

5. Attach a tachometer or frequency meter to the generator output leads if control panel does not come equipped with one of these meters. Adjust the Speed Trim pot until the desired speed is obtained.

6. Shut down and restart the genset to check for overspeed shutdown on startup.

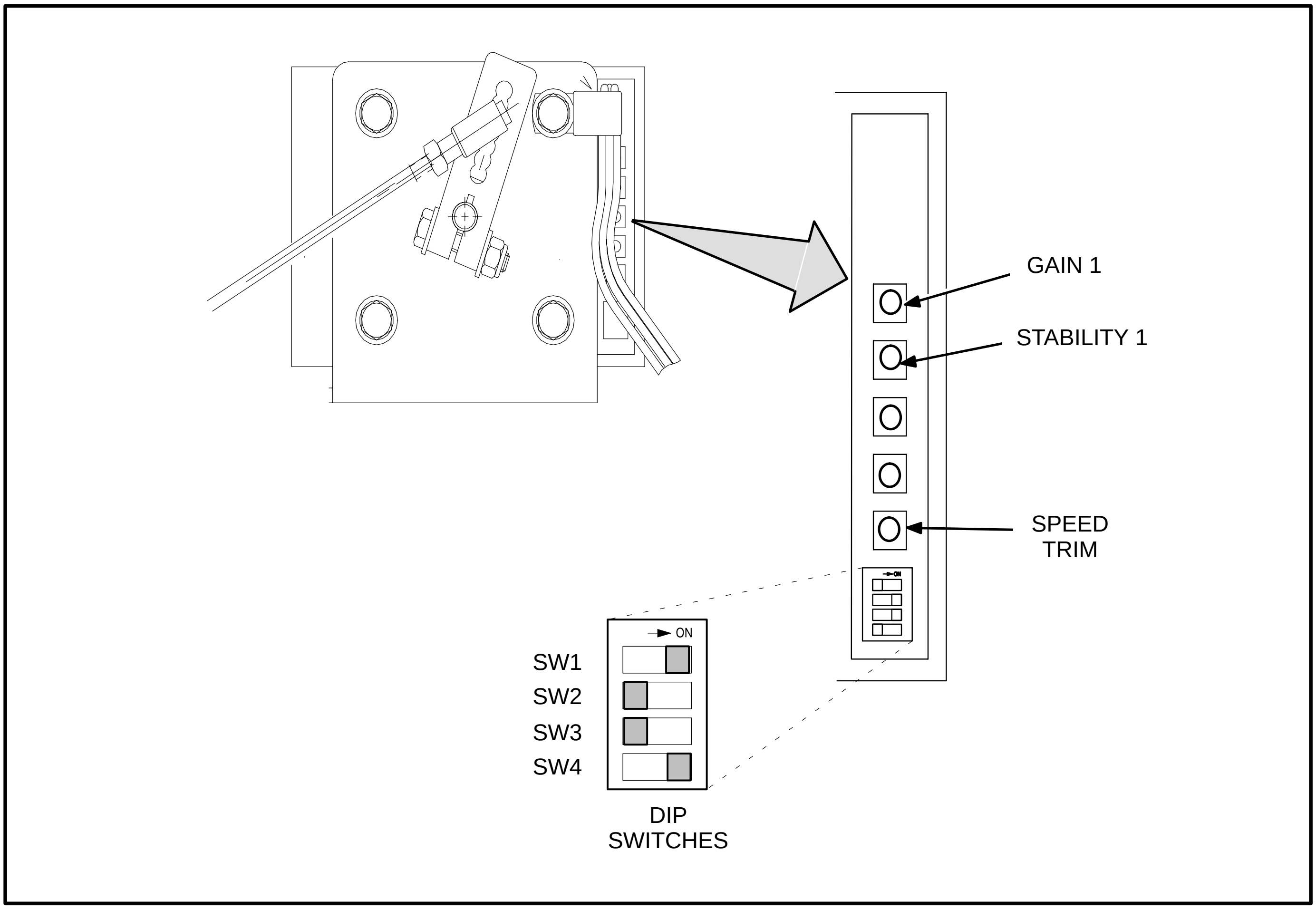


FIGURE 6-5. GOVERNOR CONTROLLER

Linkage Adjustment (Begin Spec F)

Figure 6-6 illustrates the governor linkage. Make sure that the governor controller is securely mounted to the engine bracket. To adjust the linkage:

1. With the genset stopped, check the angle of the throttle lever and governor actuator. Adjust governor lever if required. (Throttle is shown in the closed position.)
2. Verify that the ball joint screw is mounted in the third hole from the outside end of the governor arm.
3. The governor actuator shaft has 60 degrees of rotation from stop to stop. Check mounting of governor arm and linkage to assure the 60 degree actuator shaft rotation operates the throttle from closed to fully open positions.

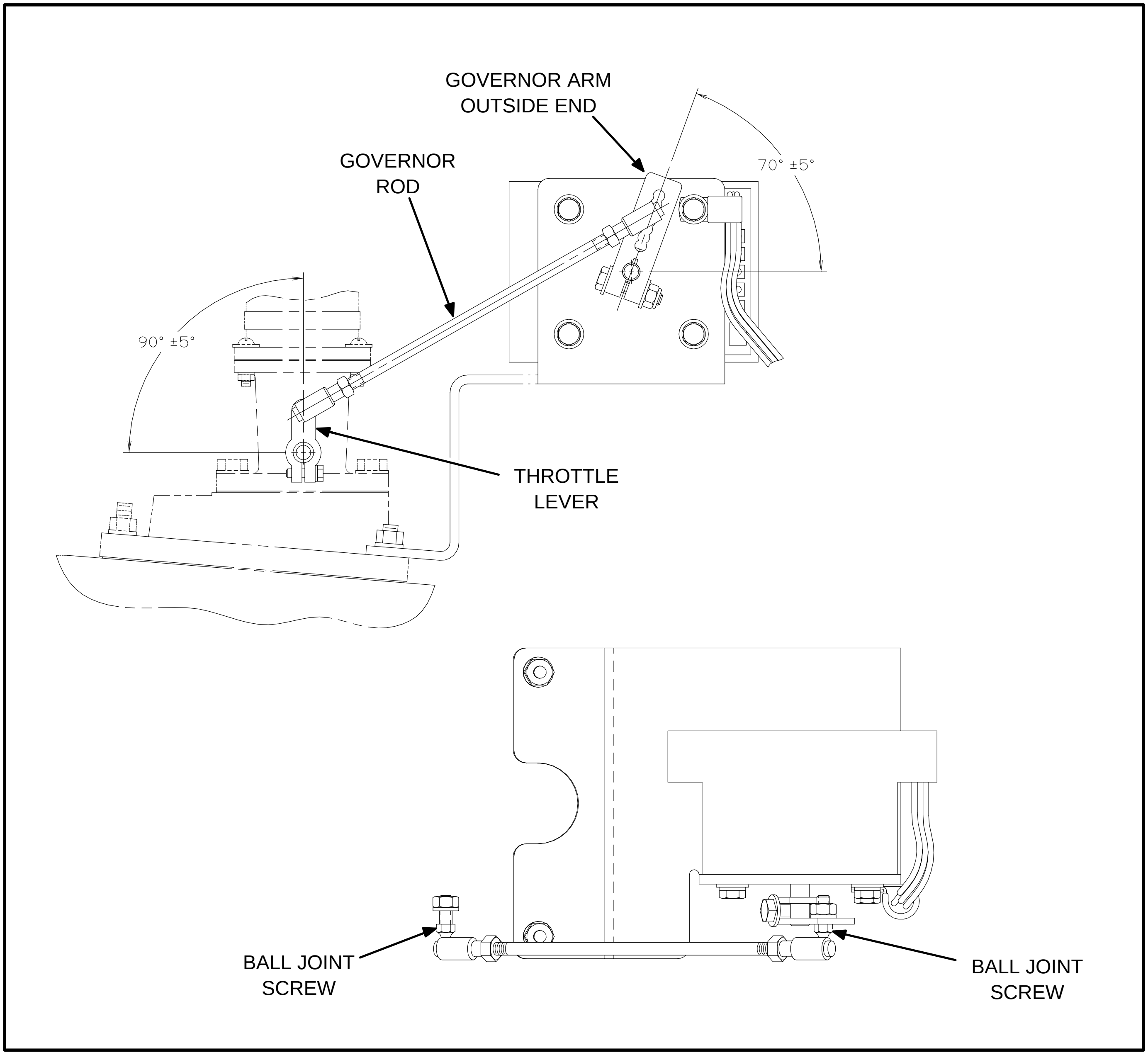


FIGURE 6-6. GOVERNOR LINKAGE

Magnetic Speed Pickup Unit Adjustment (Begin Spec F)

With the magnetic speed pickup removed from the genset, manually rotate the ring gear until a tooth lines up in the center of the mounting hole. Thread the sensor in gently by hand until it just touches the ring gear tooth. Back it out 5/8 turn and set the locknut.

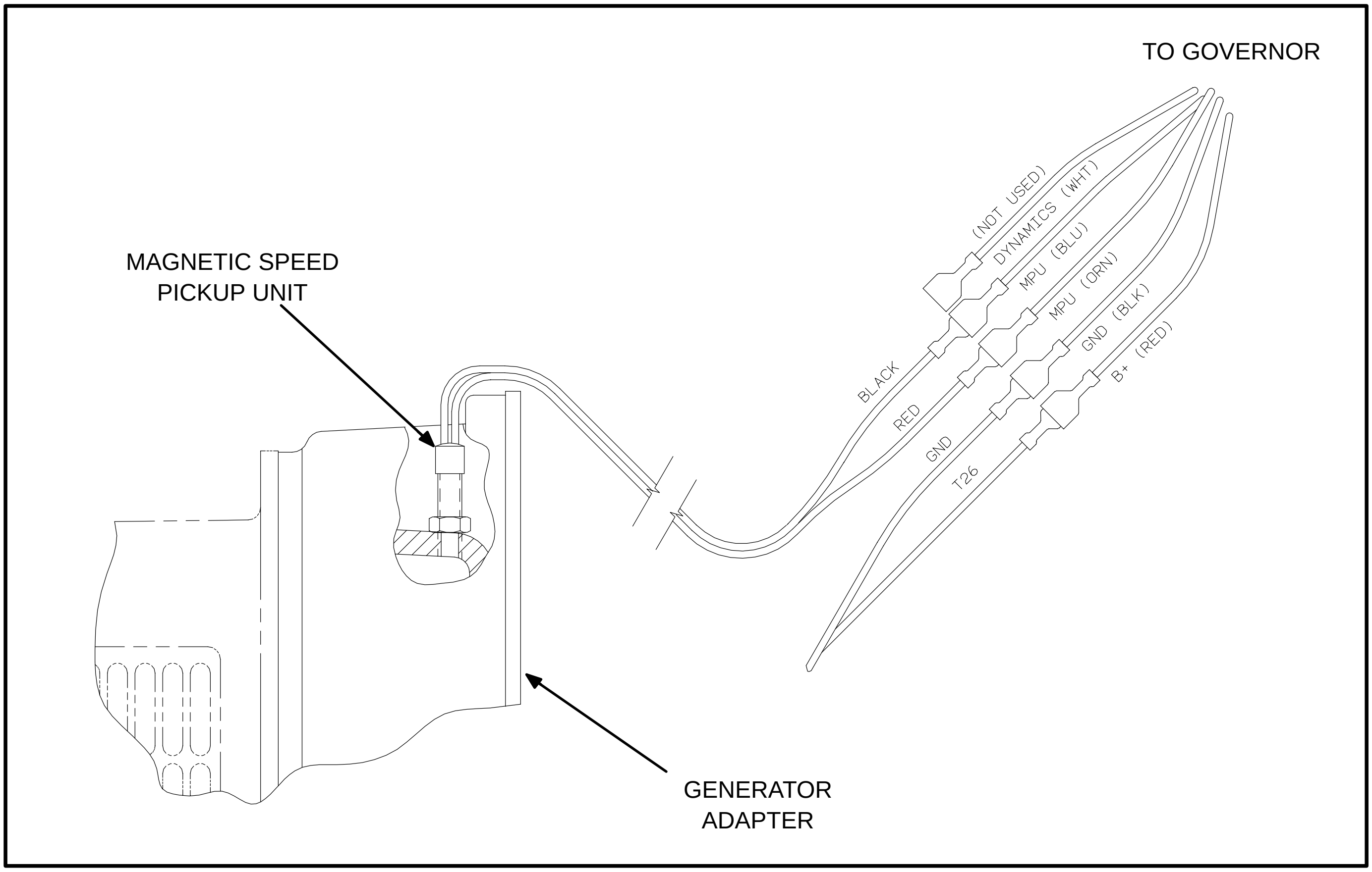


FIGURE 6-7. MAGNETIC SPEED PICKUP UNIT

CARBURETORS

The engine is equipped with a carburetor to run on regular gasoline and/or a gas mixer to run on natural gas or propane or both.

WARNING ***Fuel is highly flammable and may cause severe personal injury and property damage. Do not allow cigarettes, flame, pilot lights, arching switches or equipment in area or areas sharing ventilation.***

Gasoline Fuel System

A gasoline carburetor is provided for gasoline fuel systems. The idle mixture and choke are adjustable on the gasoline carburetor.

Idle Mixture Adjustment: If the adjustment has been disturbed or the engine performs poorly under light load, make the following adjustments.

1. Shut off the engine and turn the idle adjustment screw in gently until it bottoms, and then turn it out 2-1/2 turns so that the engine will run.

   CAUTION ***The adjustment screw and seat are easily damaged. Do not force the adjustment screw.***

2. Start the engine and let the set warm up under a partial load (at least 1/4 rated load) and then disconnect all loads.
3. Turn the idle adjustment screw out (counterclockwise) approximately one half turn and jounce the throttle. If the engine begins to hunt, turn the adjustment screw in slowly until engine speed becomes stable. If one half turn does not cause instability, turn the adjustment screw out one half turn more and repeat the procedure.

Choke Adjustment: The gasoline carburetor is equipped with an automatic choke for easier cold weather starting. The choke has a bi-metal coil that progressively closes the choke plate as ambient temperature drops, in preparation for the next start. It also has an electric heating element that heats the bi-metal coil to fully open the choke soon after the engine starts.

The choke housing cover can be rotated to adjust the choke. The perimeter of the cover is graduated with evenly spaced lines cast in it. One of the lines has an asterisk (*). For normal adjustments, the asterisk (*) should line up with the line cast in the edge of the housing.

1. For better starting in cold weather, loosen the three cover screws and rotate the cover clockwise (richer) so that the asterisk (*) is one or two lines past the line on the housing and re-tighten the cover screws.
2. For better starting in warm weather, loosen the three cover screws and rotate the cover counterclockwise (leaner) so that the asterisk (*) is one or two lines past the line on the housing and re-tighten the cover screws.

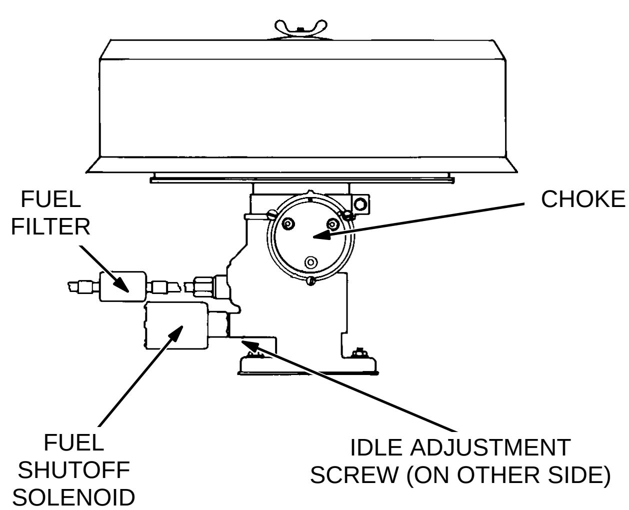


FIGURE 6-8. GASOLINE CARBURETOR

Gaseous and Combination Fuel Systems

An engine equipped for gasoline and natural gas or propane has a regular gasoline carburetor with a gas mixer mounted on the horn of the carburetor. The carburetor throttle serves both fuels. Each fuel has a separate shutoff solenoid valve. The position of the fuel selector switch (mounted at the base of the carburetor) determines which solenoid valve will open for operation.

An engine equipped for natural gas and propane has a gas mixer that serves both fuels. Each fuel has a separate shutoff solenoid valve and either and a manual fuel selector switch or a fuel pressure switch for automatic fuel changeover. (While the engine is running, the gas pressure switch causes the natural gas solenoid valve to close and the propane solenoid valve to open when natural gas pressure is lost, without stopping the engine. When natural gas pressure is restored, the natural gas solenoid valve opens and the propane solenoid valve closes.)

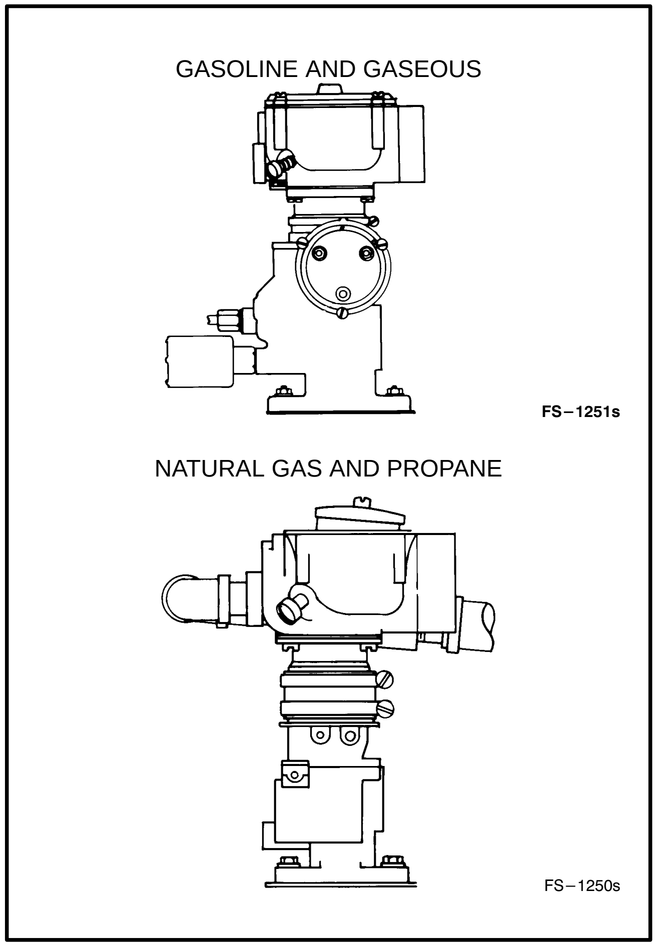


FIGURE 6-9. COMBINATION FUEL SYSTEMS

Gaseous Fuel Adjustments: Gas mixers have power and idle adjustment screws. Engines equipped for natural gas and propane also have a propane flow adjustment valve. If necessary, make the following adjustments.

1. Start the engine and let the set warm up under a partial load (at least 1/4 rated load). If the engine is equipped for natural gas and propane, start with natural gas.
2. Disconnect all loads, shut down the set, connect a tachometer and disconnect the governor linkage at the carburetor. Start the engine and close the throttle by hand so that the engine does not overspeed. While holding the throttle closed, adjust the throttle idle position screw (the one next to the throttle lever) to obtain an engine speed of 900 RPM. Then turn the idle adjusting screw counterclockwise until engine speed becomes unstable. Turn the screw clockwise just enough to regain stability and reconnect the governor linkage.
3. Next, connect full rated load and turn the power adjusting screw clockwise until the engine begins to lose speed and then slowly back out the screw (counterclockwise) until the engine carries the full load smoothly.
4. If the set is equipped for natural gas and propane, switch to propane by means of the control panel switch (if provided) or by closing the manual shutoff valve in the natural gas supply line.
5. Reconnect full rated load and turn the propane flow adjustment valve clockwise until the engine begins to lose speed and then slowly turn it back counterclockwise until the engine carries full load smoothly.

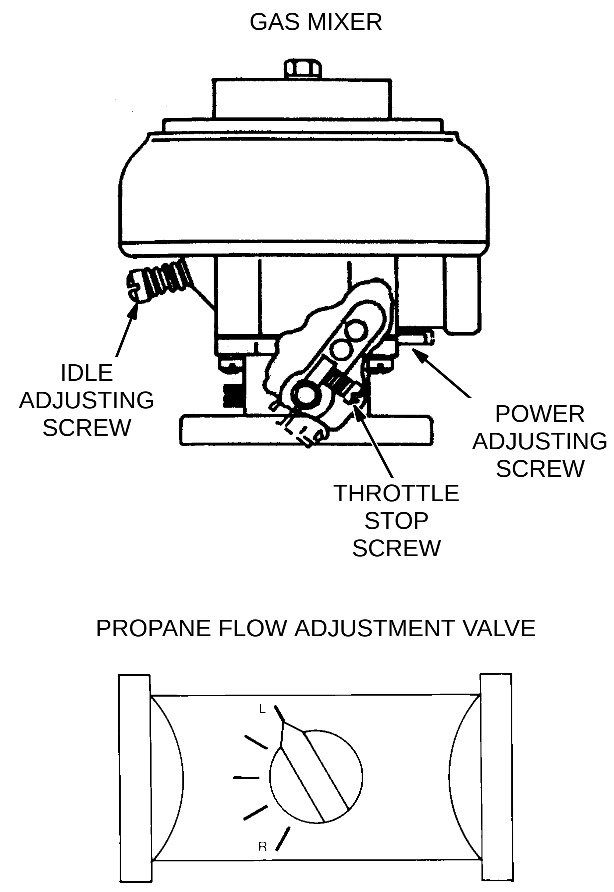


FIGURE 6-10. GASEOUS FUEL ADJUSTMENTS
FS−1176s

7. Wiring Diagrams

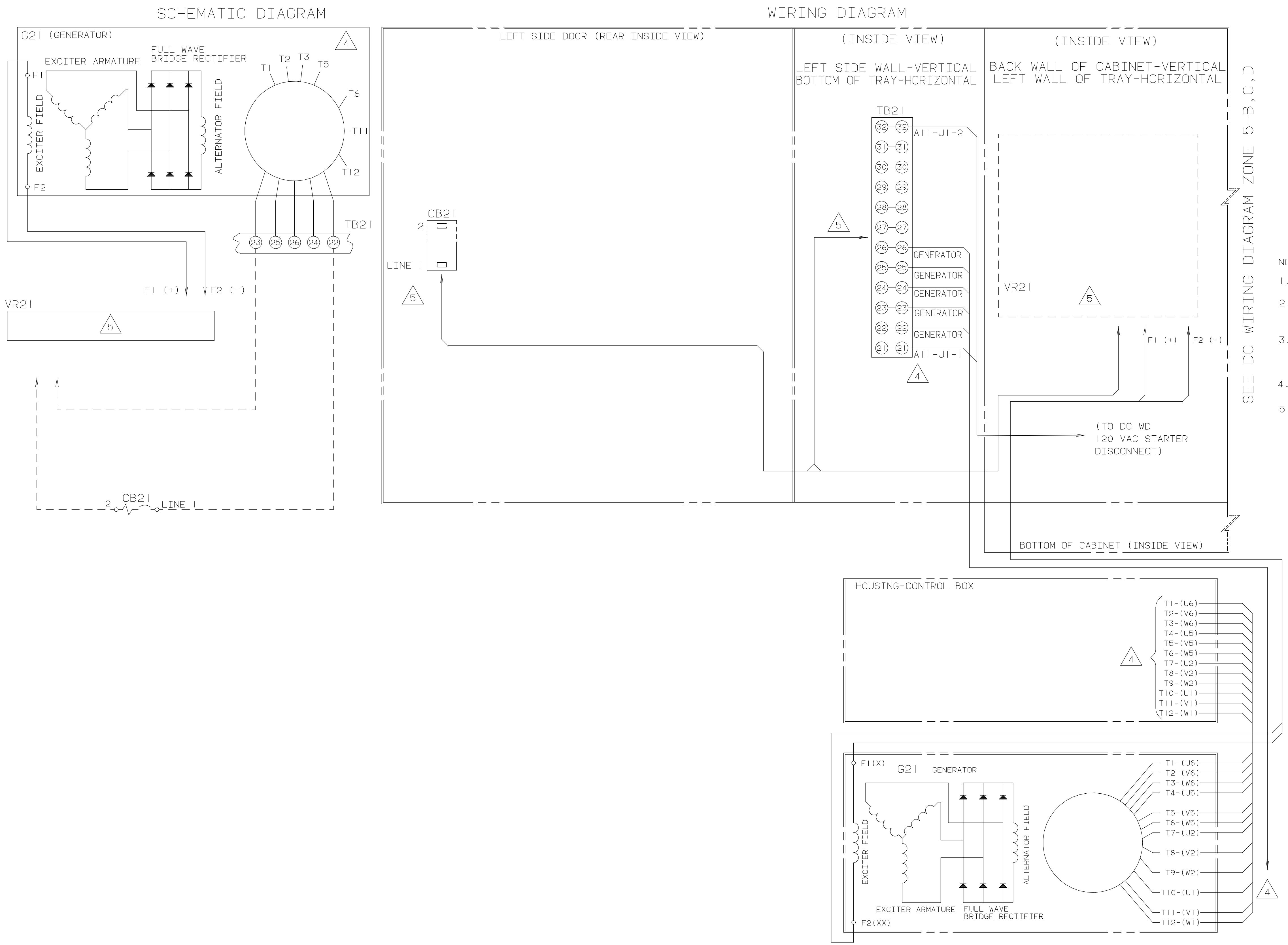
This section consists of the schematic and connection wiring diagrams referenced in the text.

The following diagrams are typical. Your genset may differ. Wiring and component specifications are subject to change. Contact your Distributor if you do not have the wiring diagrams applicable to your equipment.

The following drawings are included:

- Page 7-3 – AC Wiring (without meters)
- Page 7-4 – AC Wiring (with meters)
- Page 7-5 – Voltage Regulator Connections (MX321, PMG-excited generators))
- Page 7-6 – Voltage Regulator Connections (SX440, self-excited generators)
- Page 7-7 – 7-light DC Wiring, Sheet 1 (Prior to Spec F)
- Page 7-8 – 7-light DC Wiring, Sheet 2 (Prior to Spec F)
- Page 7-9 – 12-light DC Wiring, Sheet 1 (Prior to Spec F)
- Page 7-10 – 12-light DC Wiring, Sheet 2 (Prior to Spec F)
- Page 7-11 – 7-light DC Wiring, Sheet 1 (Begin Spec F)
- Page 7-12 – 7-light DC Wiring, Sheet 2 (Begin Spec F)
- Page 7-13 – 12-light DC Wiring, Sheet 1 (Begin Spec F)
- Page 7-14 – 12-light DC Wiring, Sheet 2 (Begin Spec F)
- Pages 7-15 and 7-16 – Reconnection Diagram (Prior to Spec E)
- Pages 7-17 and 7-18 – Reconnection Diagram (Begin Spec E)
- Page 7-19 – Typical Connections to the ECM
- Page 7-20 – Customer Connections at the Auxiliary Relay Board
- Page 7-21 – Engine Harness (Begin Spec F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



NOTES:

1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2. ILLUSTRATION NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 (D) HORIZ.
3. LOCATE ONE (1) DANGER LABEL ON EXTERIOR AND ONE (1) ON INTERIOR OF LEFT SIDE DOOR IN ANY READILY VISIBLE AREA AVAILABLE.
4. SEE GENERATOR CONNECTION DIAGRAM FOR INPUT CONNECTIONS.
5. SEE VOLTAGE REGULATOR INSTALLATION FOR CONNECTIONS TO VR21,CB21 AND TB21.

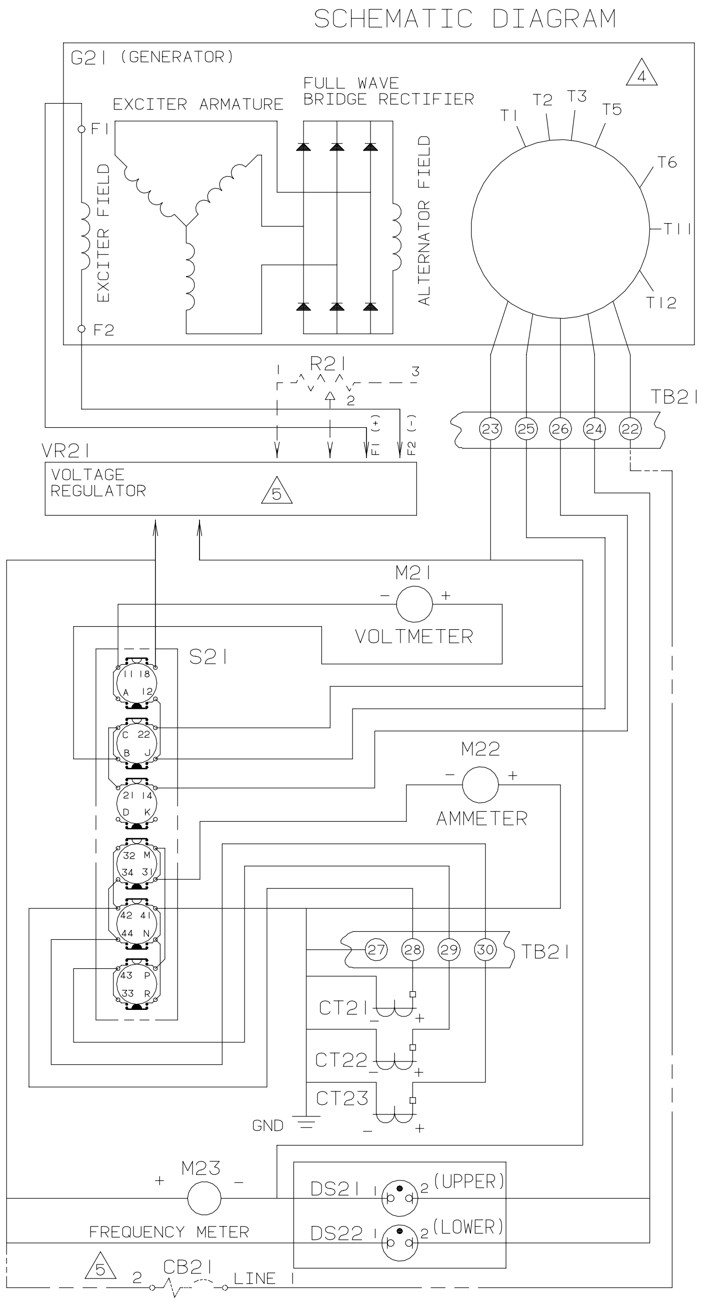
WITHOUT METERS

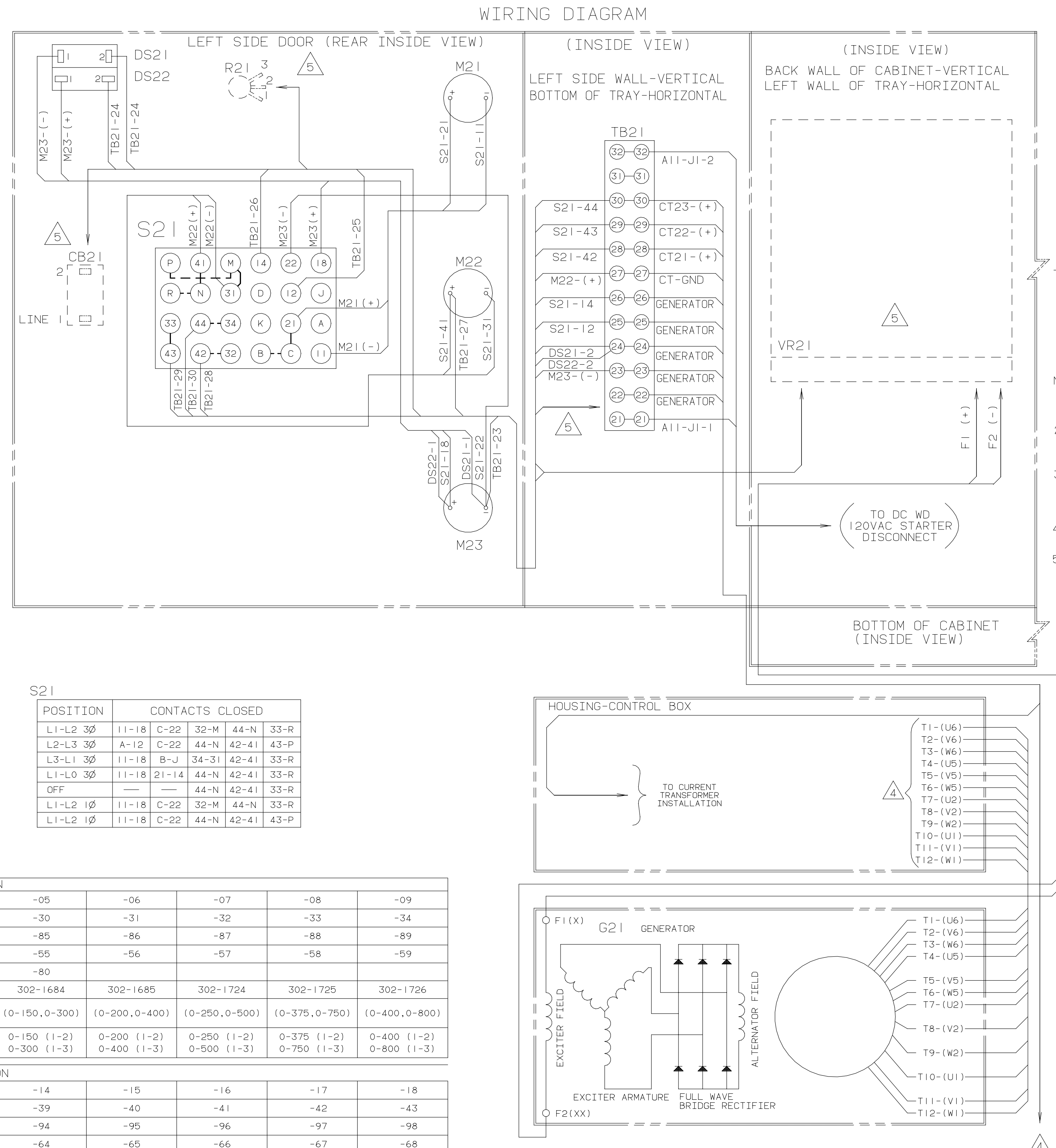
TABULATION	
VERT	-01
HORIZ	-02

NO. 612-6489
REV. D
MODIFIED

AC CONTROL WIRING DIAGRAM (WITHOUT METERS)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.





S21

POSITION	CONTACTS CLOSED				
L1-L2 3Ø	11-18	C-22	32-M	44-N	33-R
L2-L3 3Ø	A-12	C-22	44-N	42-41	43-P
L3-L1 3Ø	11-18	B-J	34-31	42-41	33-R
L1-L0 3Ø	11-18	21-14	44-N	42-41	33-R
OFF	—	—	44-N	42-41	33-R
L1-L2 1Ø	11-18	C-22	32-M	44-N	33-R
L1-L2 1Ø	11-18	C-22	44-N	42-41	43-P

NOTES:

1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2. ILLUSTRATION NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 (D) HORIZ.
3. LOCATE ONE (1) DANGER LABEL ON EXTERIOR AND ONE (1) ON INTERIOR OF LEFT SIDE DOOR IN ANY READILY VISIBLE AREA AVAILABLE.
4. SEE GENERATOR CONNECTION DIAGRAM FOR INPUT CONNECTIONS.
5. SEE VOLTAGE REGULATOR INSTALLATION FOR CONNECTIONS TO VR21,CB21,R21 AND TB21.

TABULATION

<500V	VERTICAL	-01	-02	-03	-04	-05	-06	-07	-08	-09
600V	VERTICAL	-26	-27	-28	-29	-30	-31	-32	-33	-34
MV4160	VERTICAL	-81	-82	-83	-84	-85	-86	-87	-88	-89
<500V	HORIZONTAL	-51	-52	-53	-54	-55	-56	-57	-58	-59
600V	HORIZONTAL	-76	-77	-78	-79	-80				
ITEM 32	(M22)	302-1975	302-1473	302-1147	302-1683	302-1684	302-1685	302-1724	302-1725	302-1726
AMMETER SCALE (M22)		(0-25,0-50)	(0-50,0-100)	(0-75,0-150)	(0-100,0-200)	(0-150,0-300)	(0-200,0-400)	(0-250,0-500)	(0-375,0-750)	(0-400,0-800)
CURRENT TRANSFORMER SECONDARY CONNECTION		0-25 (1-2) 0-50 (1-3)	0-50 (1-2) 0-100 (1-3)	0-75 (1-2) 0-150 (1-3)	0-100 (1-2) 0-200 (1-3)	0-150 (1-2) 0-300 (1-3)	0-200 (1-2) 0-400 (1-3)	0-250 (1-2) 0-500 (1-3)	0-375 (1-2) 0-750 (1-3)	0-400 (1-2) 0-800 (1-3)

TABULATION

<500V	VERTICAL	-10	-11	-12	-13	-14	-15	-16	-17	-18
600V	VERTICAL	-35	-36	-37	-38	-39	-40	-41	-42	-43
MV4160	VERTICAL	-90	-91	-92	-93	-94	-95	-96	-97	-98
<500V	HORIZONTAL	-60	-61	-62	-63	-64	-65	-66	-67	-68
600V	HORIZONTAL									
ITEM 32	(M22)	302-1727	302-1728	302-1729	302-1798	302-1799	302-1800	302-1908		
AMMETER SCALE (M22)		(0-500,0-1000)	(0-600,0-1200)	(0-750,0-1500)	(0-1000,0-2000)	(0-1500,0-3000)	(0-2000,0-4000)	(0-3000;0-6000)		
CURRENT TRANSFORMER SECONDARY CONNECTION		0-500 (1-2) 0-1000 (1-3)	0-600 (1-2) 0-1200 (1-3)	0-750 (1-2) 0-1500 (1-3)	0-1000 (1-2) 0-2000 (1-3)	0-1500 (1-2) 0-3000 (1-3)	0-2000 (1-2) 0-4000 (1-3)	0-3000 (1-2) 0-6000 (1-3)		

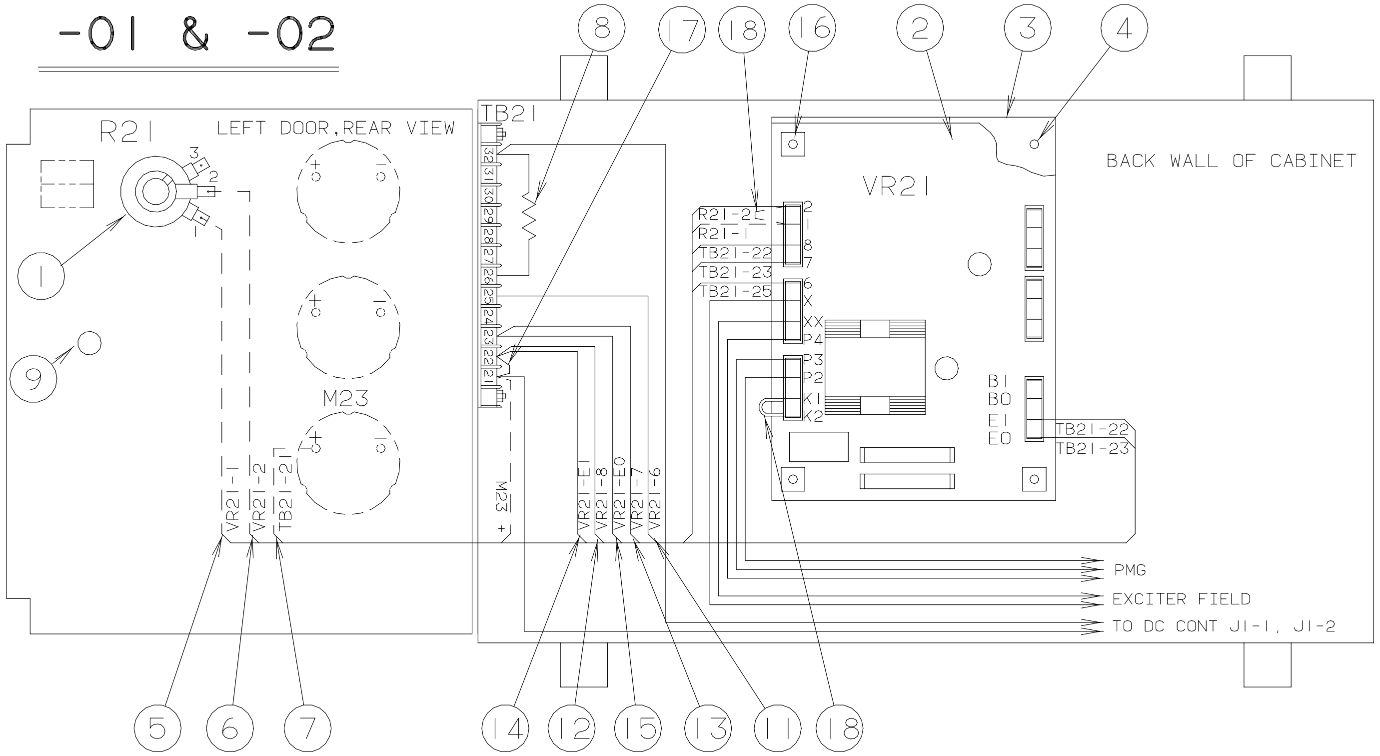
WITH METERS

NO. 612-6490
REV. J
MODIFIED

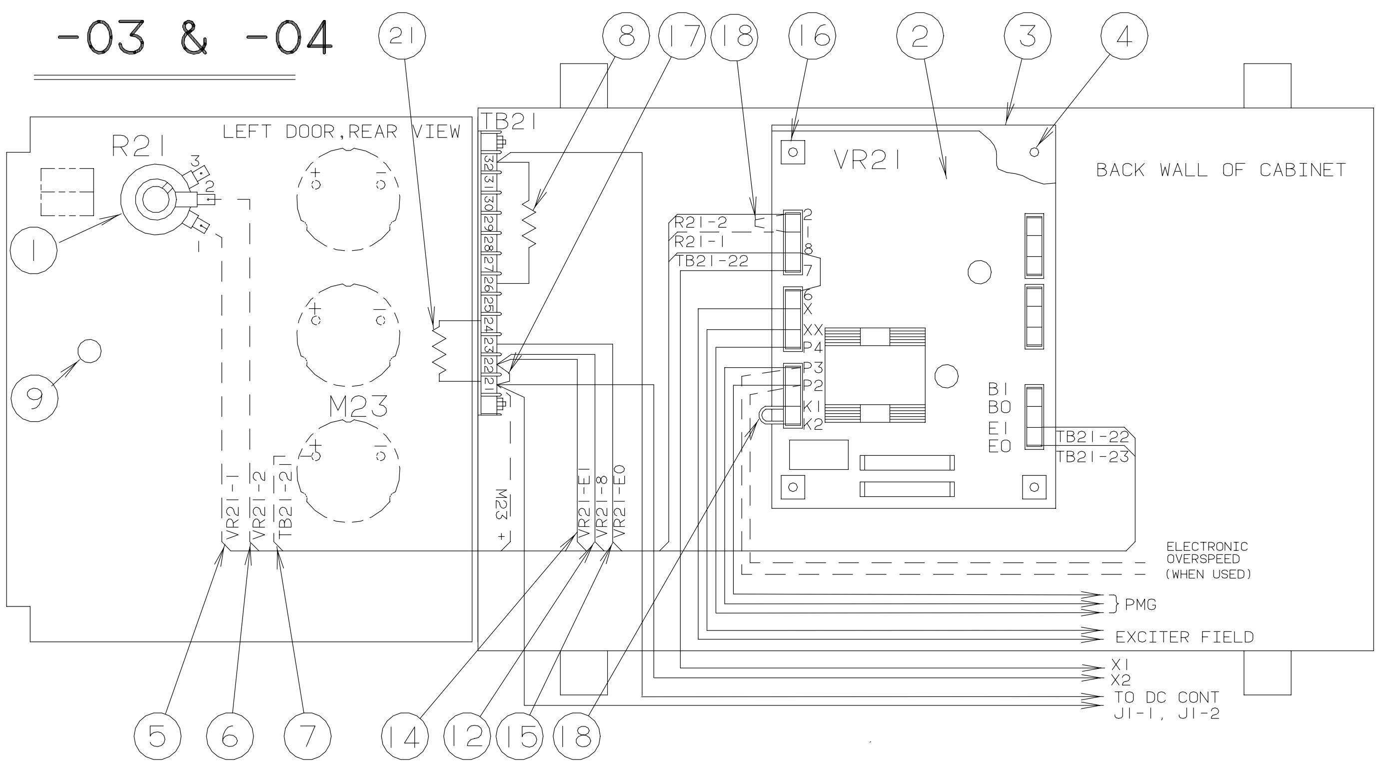
AC CONTROL WIRING DIAGRAM (WITH METERS)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

-01 & -02



-03 & -04



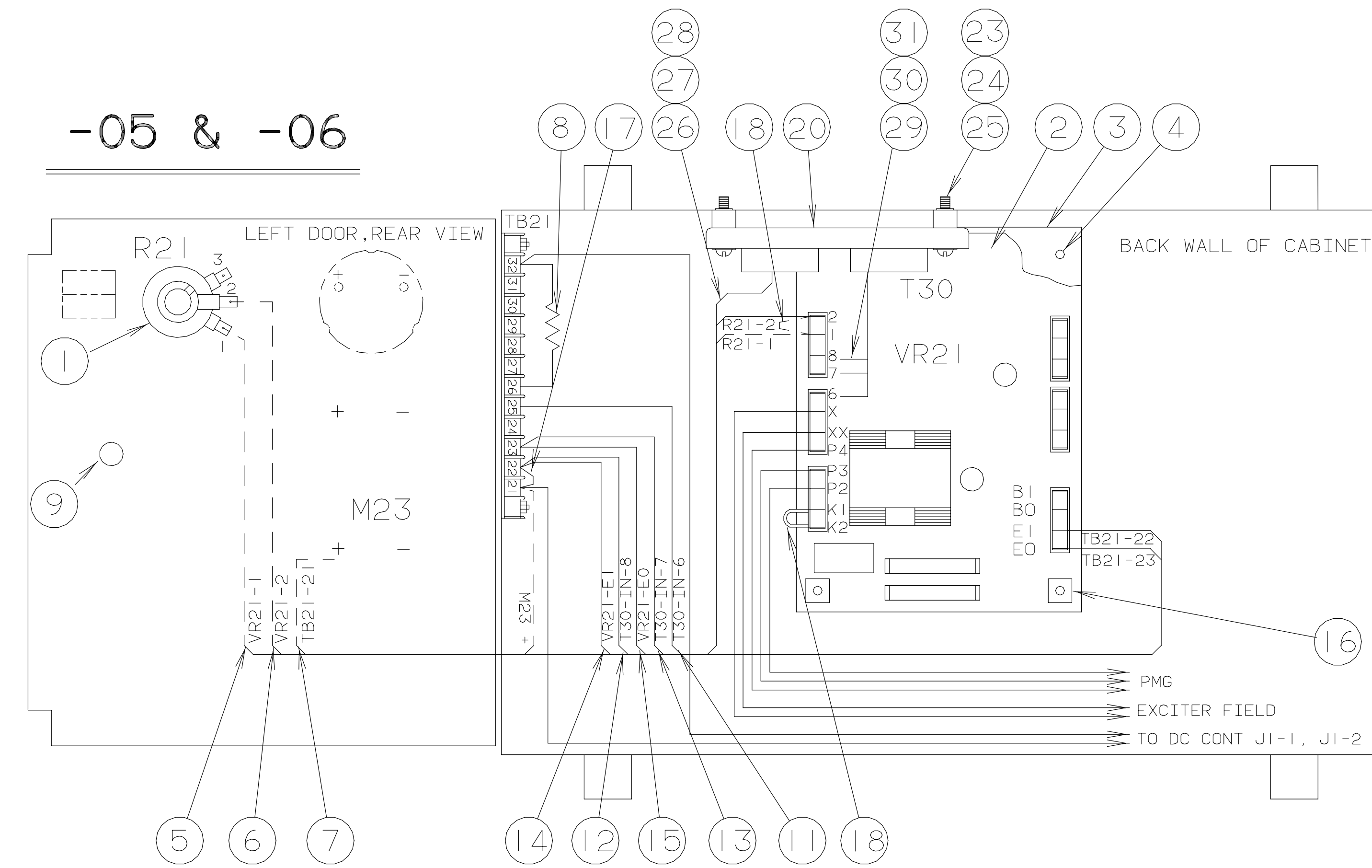
MX321

NOTES

1. DASHED LEADS INDICATE WHEN USED
2. REFER TO ILLUSTRATION DRAWING 539-0741
3. TIE EXTRA WIRE INTO HARNESS

ITEM	QTY	DESCRIPTION OR MATERIAL
31	TAB	LEAD (T30-OUT-6; VR21-6)
30	TAB	LEAD (T30-OUT-7; VR21-7)
29	TAB	LEAD (T30-OUT-8; VR21-8)
28	TAB	LEAD (T30-IN-7; TB21-23
27	TAB	LEAD (T30-IN-8; TB21-22
26	TAB	LEAD (T30-IN-6; TB21-25
25	TAB	LOCKWASHER #10
24	TAB	WASHER-FLAT #10
23	TAB	SCREW-RHSM (10-32 X 1-1/2)
22	TAB	TERMINAL - TAB ADAPTOR
21	TAB	RESISTOR ASSY
20	TAB	TRANSFORMER PCB-ISLN
19		
18	TAB	LEAD (VR21-1; VR21-2)
17	1	JUMPER
16	4	SCREW-RHM (8-32X1)
15	1	LEAD (VR21-E0;TB21-23)
14	1	LEAD (VR21-E1;TB21-22)
13	1	LEAD (VR21-7;TB21-23)
12	1	LEAD (VR21-8;TB21-22)
11	1	LEAD (VR21-6;TB21-25)
10		
9	1	PLUG-HOLE
8	1	RESISTOR ASSY
7	TAB	LEAD (TB21-21;M23 +)
6	TAB	LEAD (R21-2;VR21-2)
5	TAB	LEAD (VR21-1;R21-1)
4	6	SCREW-LKH (6-32X1/2)
3	1	PLATE-VOLT RGLTR MTG
2	1	VOLTAGE REGULATOR
1	TAB	POTENTIOMETER

-05 & -06



TABULATION

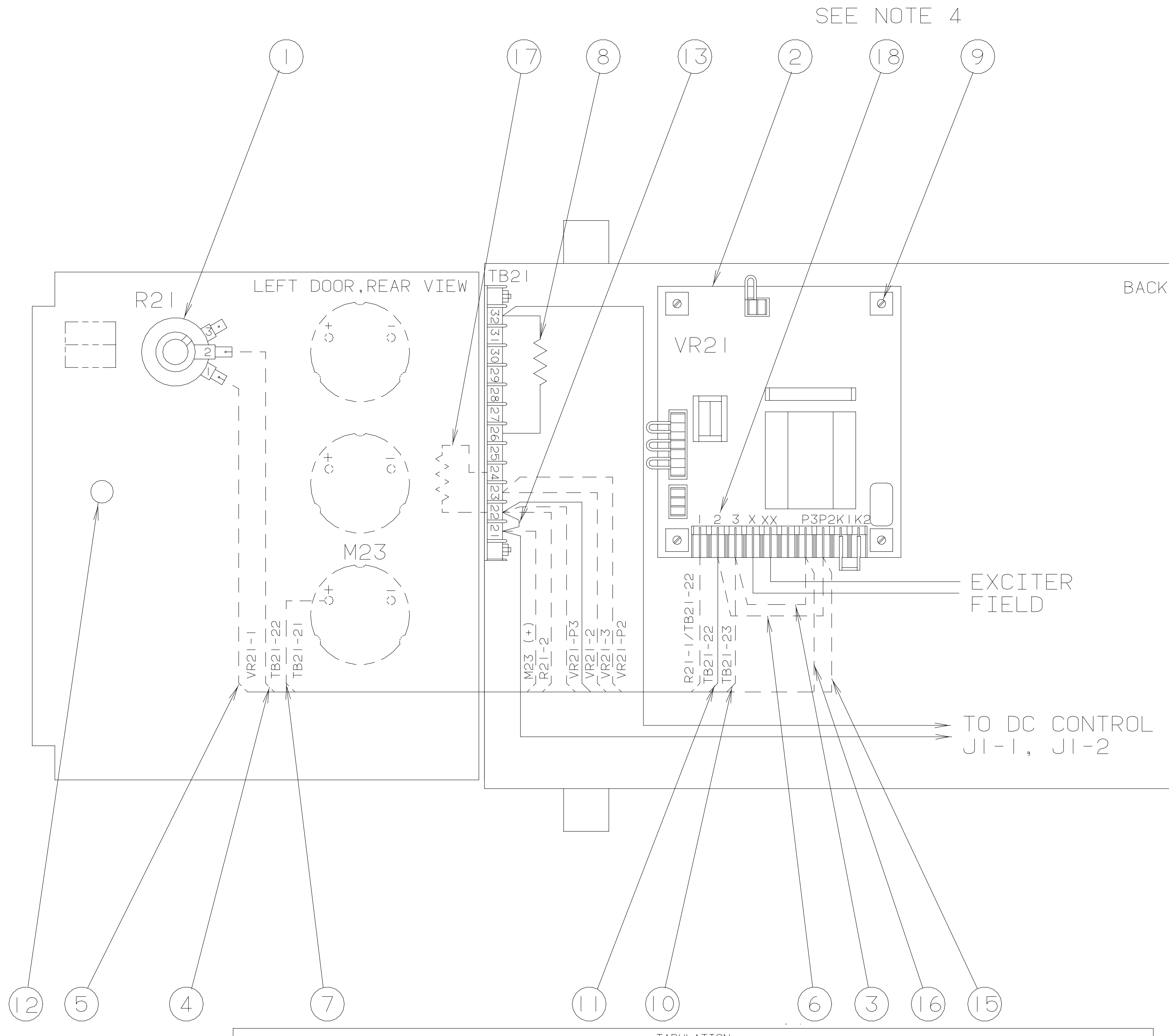
	DASH NO.	WITH PNL VOLTAGE ADJUST	W/OUT PNL VOLTAGE ADJUST	QTY. ITEM 1	QTY. ITEM 5	QTY. ITEM 6	QTY. ITEM 7	QTY. ITEM 18	QTY. ITEM 20	QTY. ITEM 21	QTY. ITEM 22	QTY. ITEM 23	QTY. ITEM 24	QTY. ITEM 25	QTY. ITEM 26	QTY. ITEM 27	QTY. ITEM 28	QTY. ITEM 29	QTY. ITEM 30	QTY. ITEM 31
	-01	-	X	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
	-02	X	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
*	-03	-	X	-	-	-	-	2	-	1	1	-	-	-	-	-	-	-	-	-
*	-04	X	-	1	1	1	1	1	-	1	1	-	-	-	-	-	-	-	-	-
	-05	-	X	-	-	-	-	2	1	-	-	4	4	4	1	1	1	1	1	1
	-06	X	-	1	1	1	1	1	1	-	-	4	4	4	1	1	1	1	1	1

* -03 & -04 ARE QUIET SITE I & II WITH RECONNECT PANEL. REGULATOR IS CONNECTED FOR 2 PHASE SENSING.

NO. 300-3606
REV. G
MODIFIED

VOLTAGE REGULATOR INSTALLATION (PMG-EXCITED GENERATORS)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



TABULATION														
DASH NO.	WITH PANEL VOLTAGE ADJUST	WITHOUT PANEL VOLTAGE ADJUST	QTY. ITEM 1	QTY. ITEM 3	QTY. ITEM 4	QTY. ITEM 5	QTY. ITEM 6	QTY. ITEM 7	QTY. ITEM 10	QTY. ITEM 14	QTY. ITEM 15	QTY. ITEM 16	QTY. ITEM 17	QTY. ITEM 18
-01	-	X	-	1	-	-	1	-	1	1	-	-	-	-
-02	X	-	1	1	1	1	1	1	1	-	-	-	-	-
-03	-	X	-	-	-	-	-	-	-	1	1	1	1	1
-04	X	-	1	-	1	1	-	1	-	-	1	1	1	1

NOTES

1. DASHED LEADS INDICATE WHEN USED
2. REFER TO ILLUSTRATION DRAWING 539-0741
3. TIE EXTRA WIRE INTO HARNESS
4. ON -03,-04 USE ITEM 18 TO CONNECT LEAD TO VR21-2.

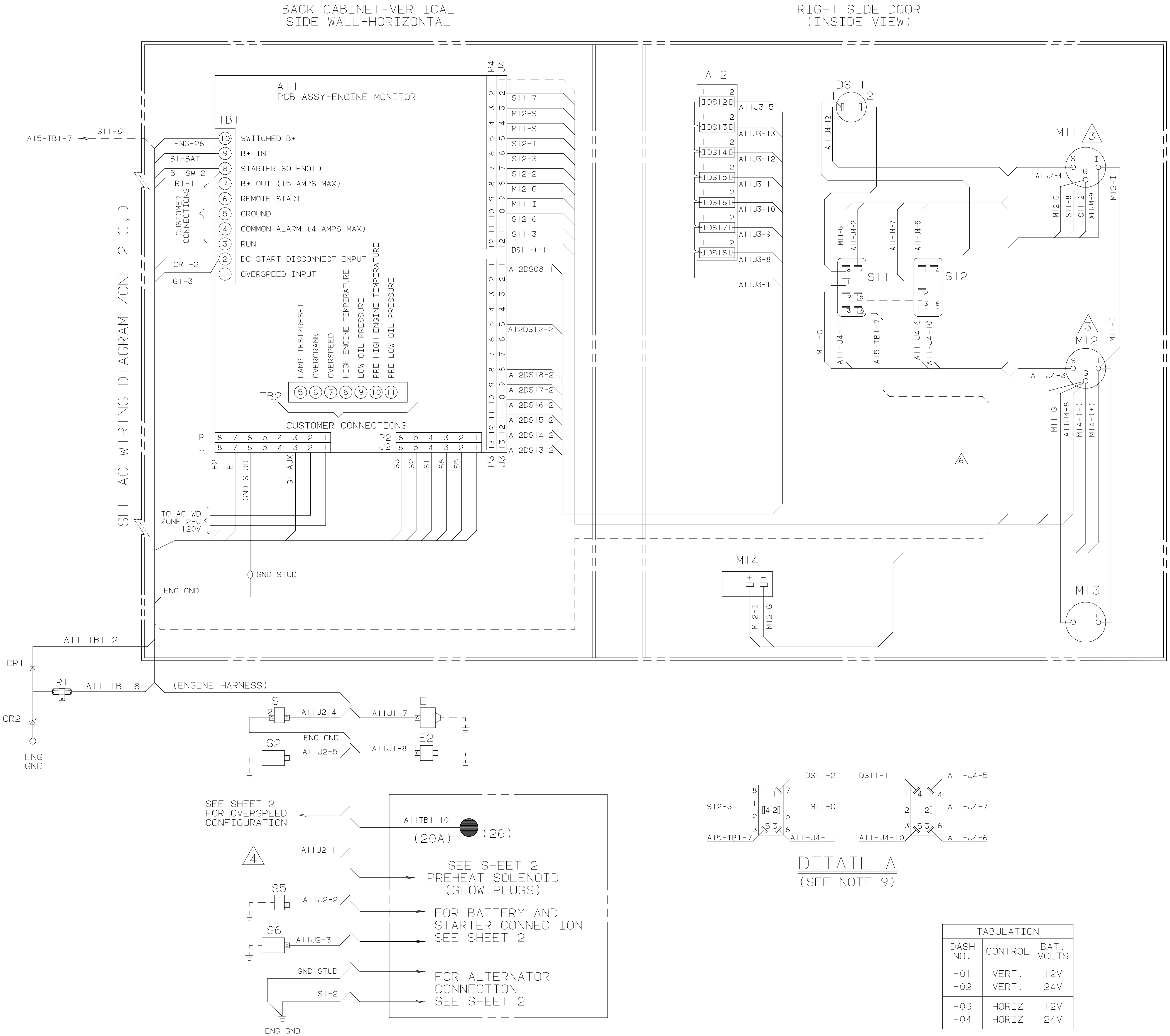
ILLUS NO	ITEM	QTY	DESCRIPTION OR MATERIAL
	18	TAB	TERMINAL-TAB ADAPTOR
	17	TAB	RESISTOR ASSY
	16	TAB	LEAD (VR21-P3 TB21-22)
	15	TAB	LEAD (VR21-P2 TB21-23)
	14	TAB	LEAD (VR21-1:TB21-22)
	13	1	JUMPER
	12	1	PLUG-HOLE
	11	1	LEAD (VR21-2;TB21-22)
	10	TAB	LEAD (TB21-23;VR21-3)
18	9	4	SCREW-LKH 8-32X 1
	8	1	RESISTOR ASSY
	7	TAB	LEAD (TB21-21;M23(+))
	6	TAB	LEAD (VR21-3: VR21-P3)
	5	TAB	LEAD (VR21-1;R21-1)
	4	TAB	LEAD (TB21-22;R21-2)
	3	TAB	LEAD (VR21-2; VR21-P2)
43	2	1	VOLTAGE REGULATOR
38	1	TAB	POTENTIOMETER

SX440

NO. 300-3607
REV. D
MODIFIED

VOLTAGE REGULATOR INSTALLATION (SELF-EXCITED GENERATORS)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



NOTES:

1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION
2. ILLUSTRATION NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 HORIZ.
3. GAUGE RESISTORS R12,13 (ILLUS #88) ARE USED ON 24V (-02,-04) VERSION ONLY. MOUNT BEFORE ATTACHING HARNESS.
4. TIE ALL UNUSED LEADS INTO HARNESS
5. GROUND BETWEEN M11 & M12 (ILLUS #77,78) IS THROUGH THE FRONT PANEL.
6. DASHED LEADS INDICATE WHEN USED.
8. ITEMS CR1, CR2, R1, AND LEAD G1-3 TO A11-TB1-2 ARE USED ONLY ON THE CUMMINS B & C BLOCK ENGINES USING THE DELCO/MOTOROLA ALTERNATOR.
9. ON SOME SETS YOU MAY HAVE THIS INTERIM SILKSCREEN AND WIRING CONFIGURATION.

REF DES	QTY	DESCRIPTION
S6		THERMOSTAT (PRE-HET)
S5		SWITCH-PRESS (PRE-LOP)
S3		SWITCH-OVERSPEED
S2		THERMOSTAT (HET)
S1		SWITCH-OIL PRESS (LOP)
K4		STARTER PILOT SOLENOID
K2		PREHEAT SOLENOID (GLOW PLUGS)
K1		FUEL SOLENOID
G1		ALTERNATOR
E2		SENDER-WATER TEMP
E1		SENDER-OIL PRESSURE
BT1		BATTERY-STORAGE
B1		STARTER & SOLENOID

ENGINE PARTS LIST ABOVE (SHOWN FOR REFERENCE ONLY)

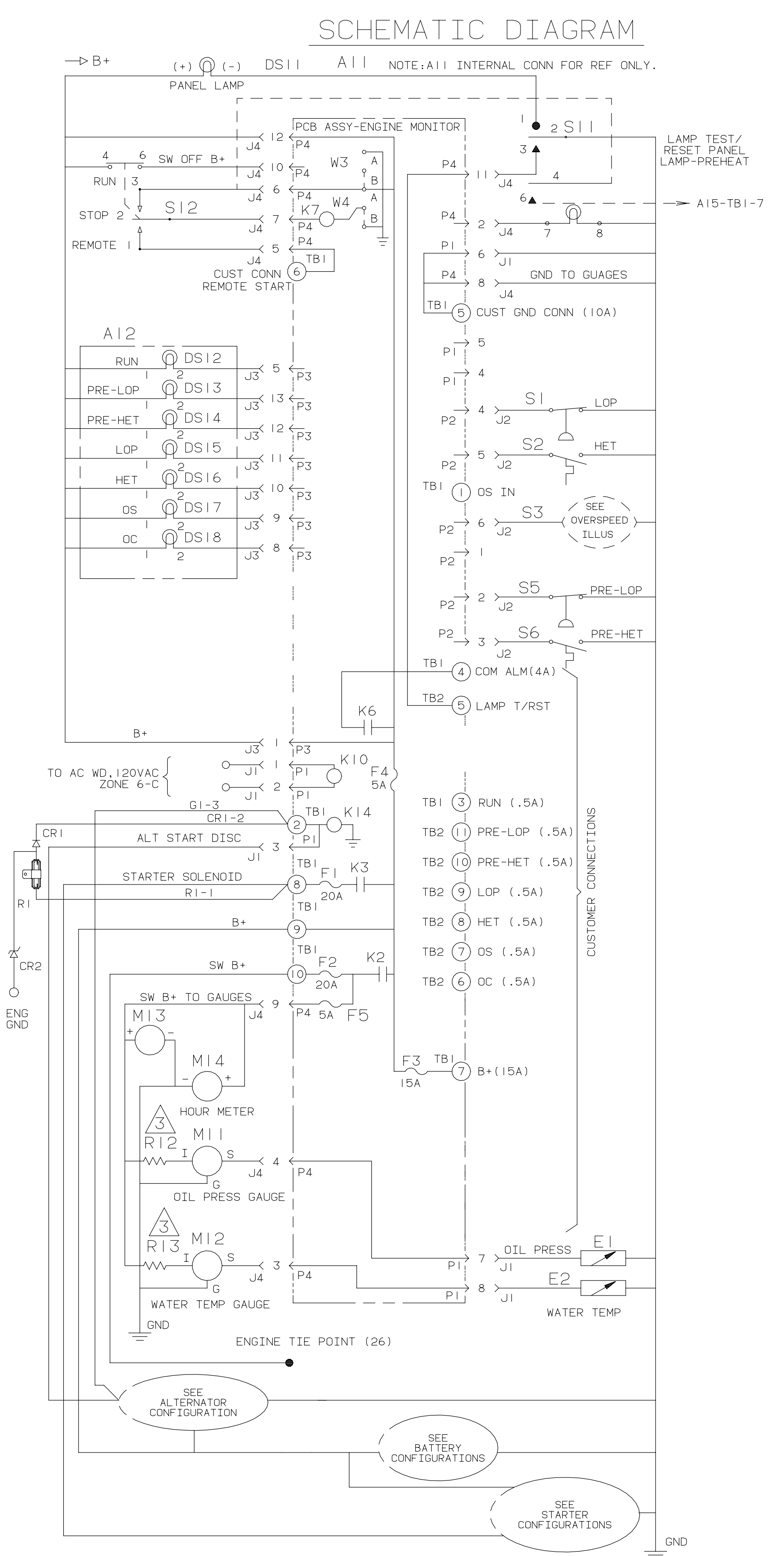
TABULATION

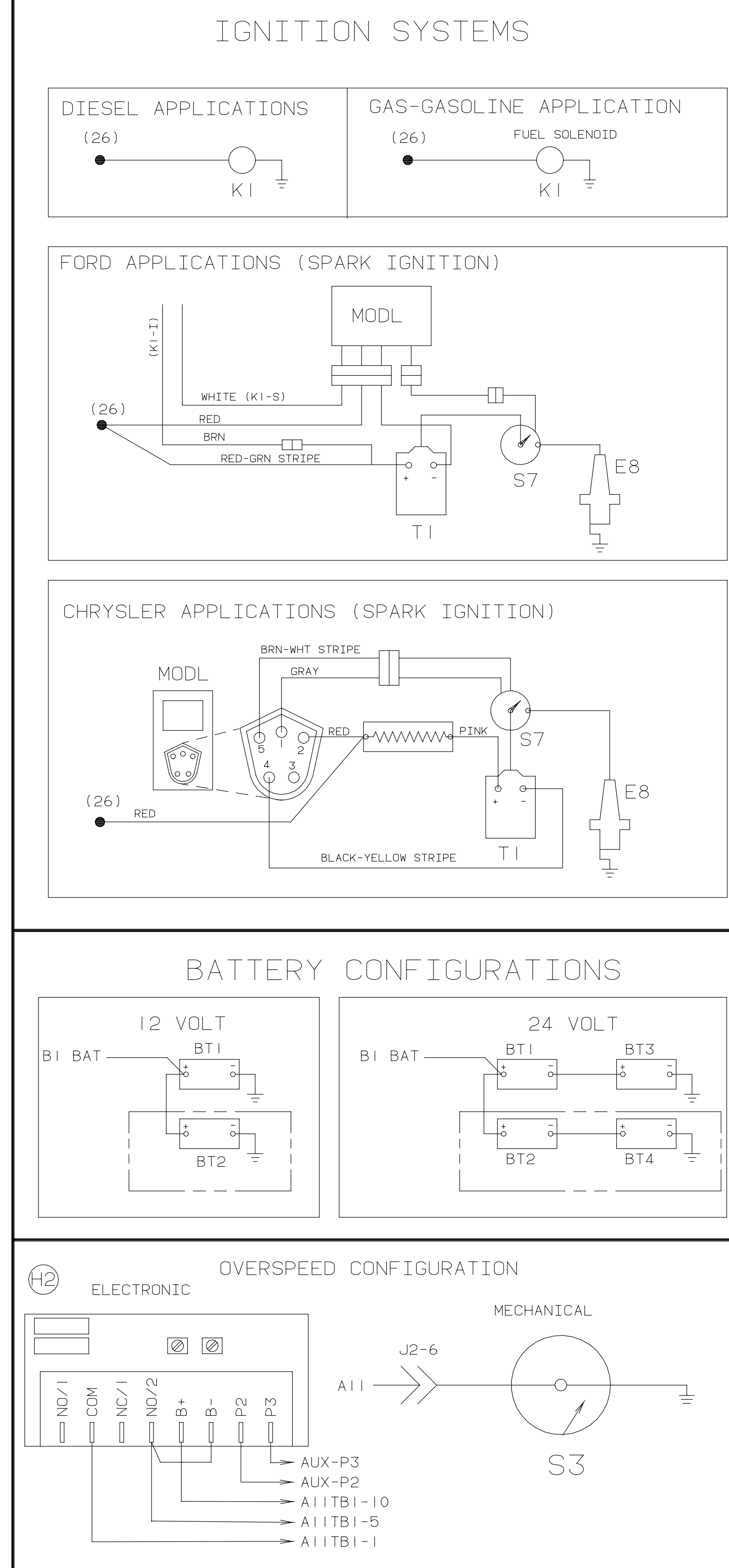
DASH NO.	CONTROL	BAT. VOLTS
-01	VERT.	12V
-02	VERT.	24V
-03	HORIZ	12V
-04	HORIZ	24V

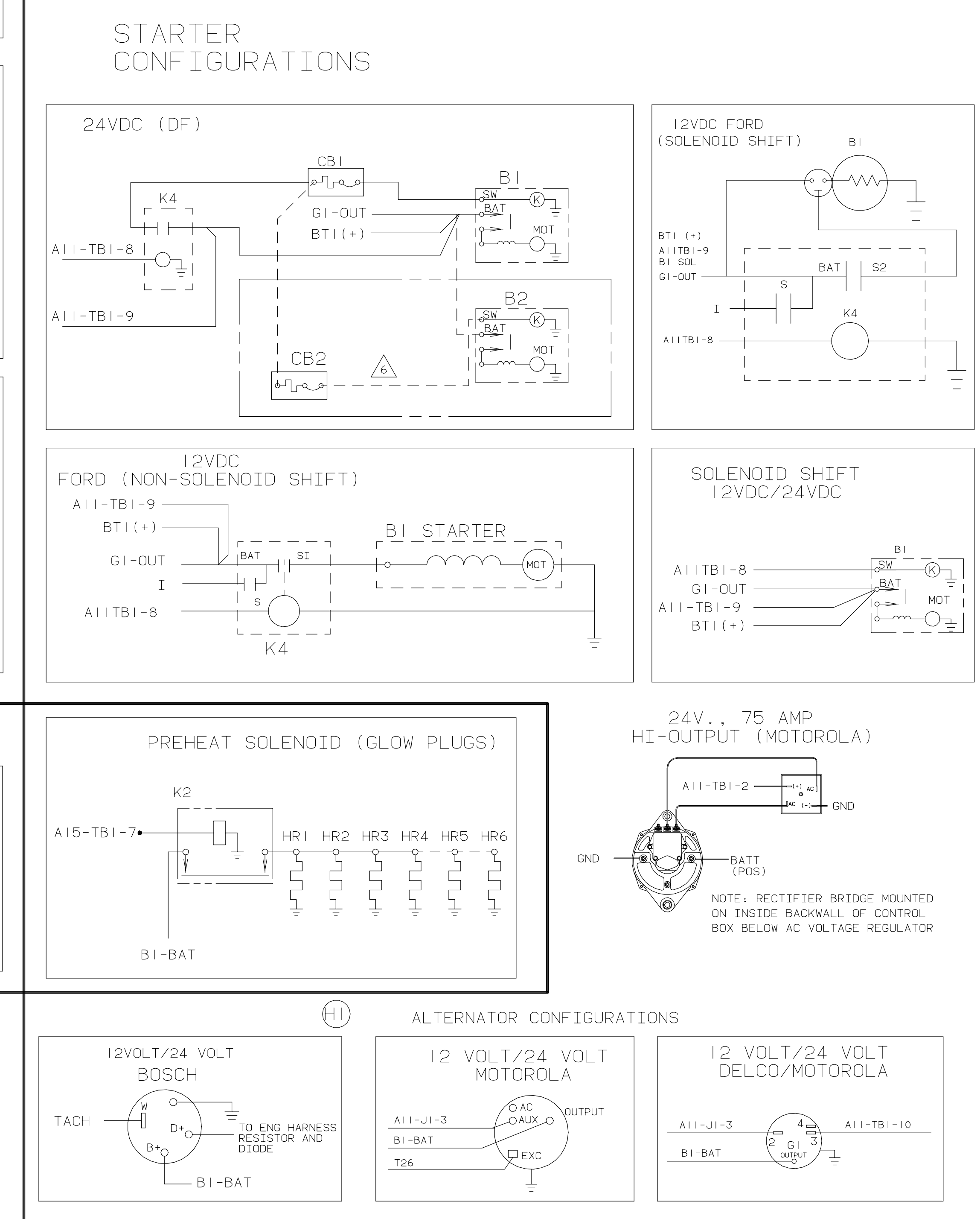
No. 612–6487 sh 1 of 2
Rev. N Sys:CADAM
Modified 8/3/95

7-LIGHT DC WIRING, SHEET 1 (PRIOR TO SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



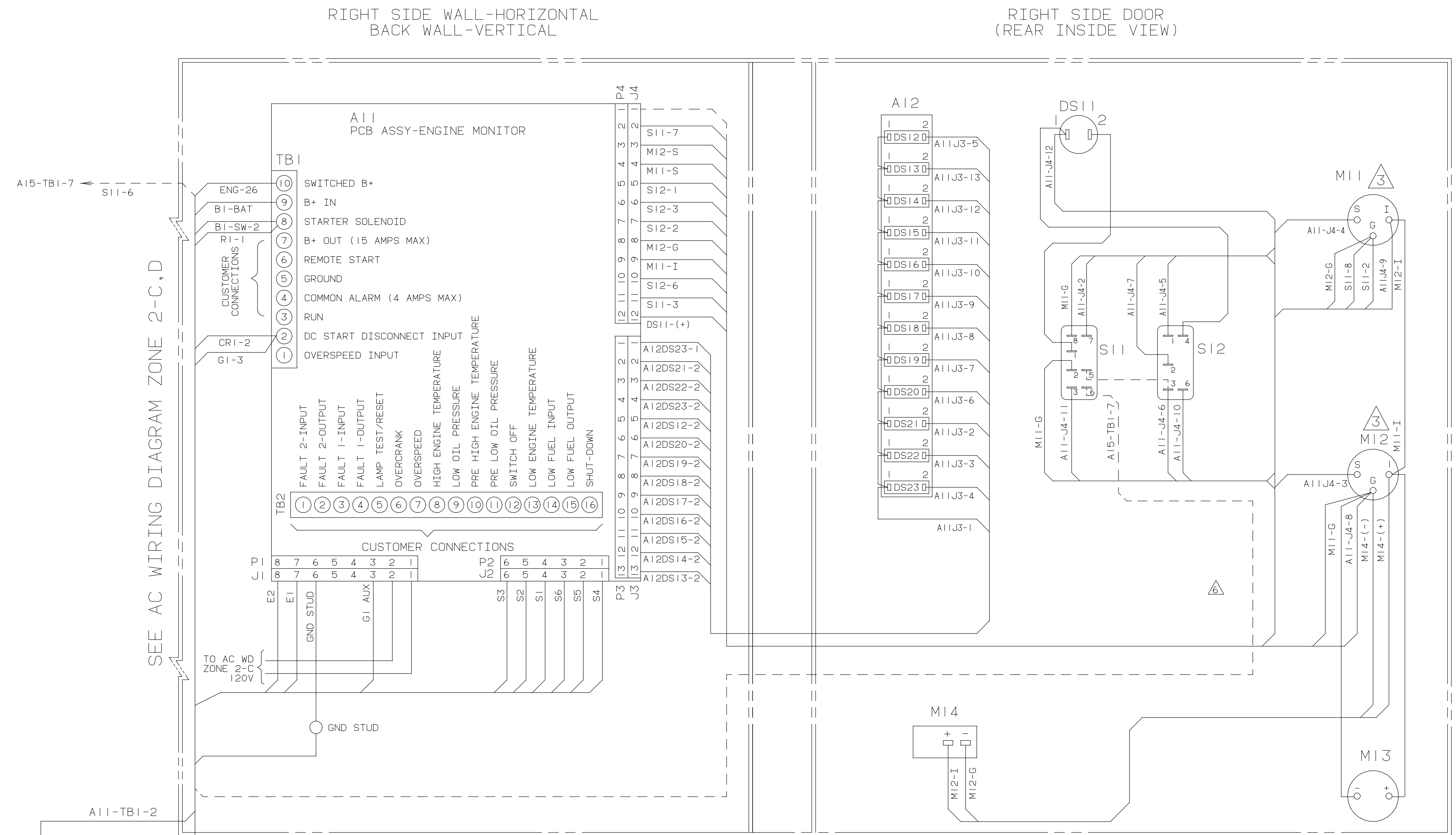


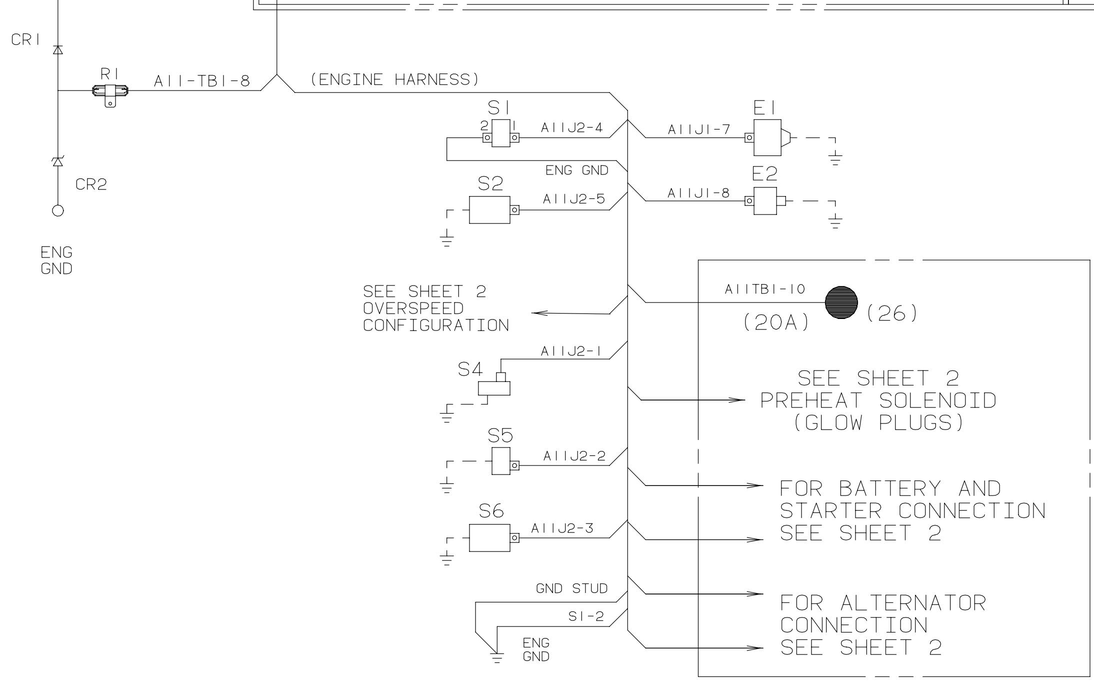


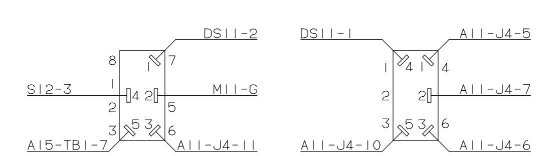
No. 612–6487 sh 2of 2
Rev. N Sys: CADAM
Modified 8/3/95

7-LIGHT DC WIRING, SHEET 2 (PRIOR TO SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.







DETAIL A
(SEE NOTE 9)

NOTES:

1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2. ILLUSTRATION NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 HORIZ.
3. GAUGE RESISTORS R12,13 (ILLUS #88) ARE USED ON 24V (-02,-04) VERSION ONLY. MOUNT BEFORE ATTACHING HARNESS.
4. TIE ALL UNUSED LEADS INTO HARNESS
5. GROUND BETWEEN M11 & M12 (ILLUS #77,78) IS THROUGH THE FRONT PANEL.
6. DASHED LEADS INDICATE WHEN USED.
8. ITEMS CR1, CR2, R1, AND LEAD G1-3 TO A11-TB1-2 ARE USED ONLY ON THE CUMMINS B & C BLOCK ENGINES USING THE DELCO/MOTOROLA ALTERNATOR
9. ON SOME SETS YOU MAY HAVE THIS INTERIM SILKSCREEN AND WIRING CONFIGURATION.

REF DES	QTY	DESCRIPTION
S6		THERMOSTAT (PRE-HET)
S5		SWITCH-PRESS (PRE-LOP)
S4		SWITCH LOW ENGINE TEMP
S3		SWITCH-OVERSPEED
S2		THERMOSTAT (HET)
S1		SWITCH-OIL PRESS (LOP)
K4		STARTER PILOT SOLENOID
K2		PREHEAT SOLENOID (GLOW PLUGS)
K1		FUEL SOLENOID
G1		ALTERNATOR
E2		SENDER-WATER TEMP
E1		SENDER-OIL PRESSURE
BT1		BATTERY-STORAGE
B1		STARTER & SOLENOID

ENGINE PARTS LIST ABOVE (SHOWN FOR REFERENCE ONLY)

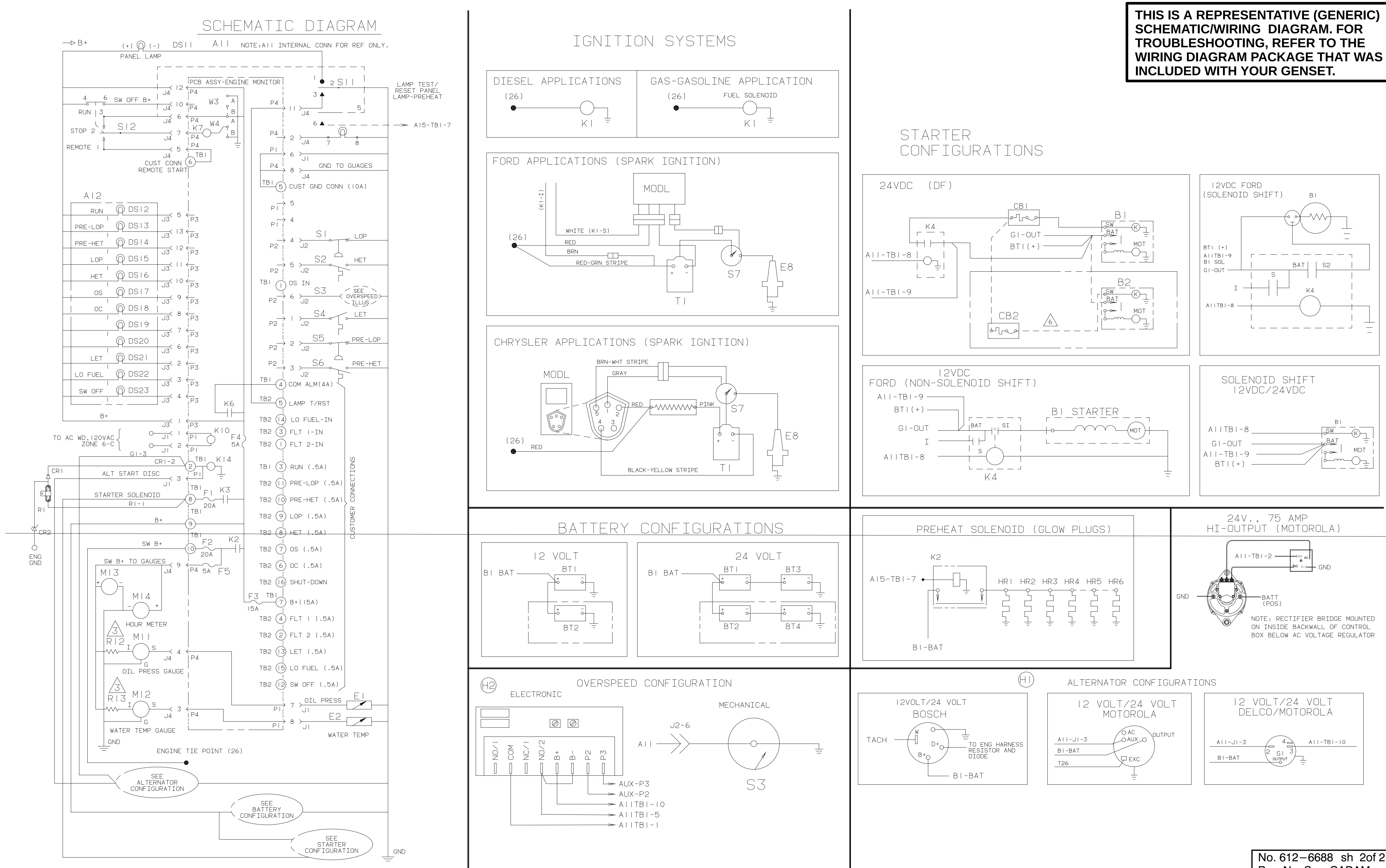
TABULATION

DASH NO.	CONTROL	BAT. VOLTS
-01	VERT.	12V
-02	VERT.	24V
-03	HORIZ	12V
-04	HORIZ	24V

No. 612−6488 sh 1of 2
Rev. N Sys: CADAM
Modified 8/3/95

12-LIGHT DC WIRING, SHEET 1 (PRIOR TO SPEC F)

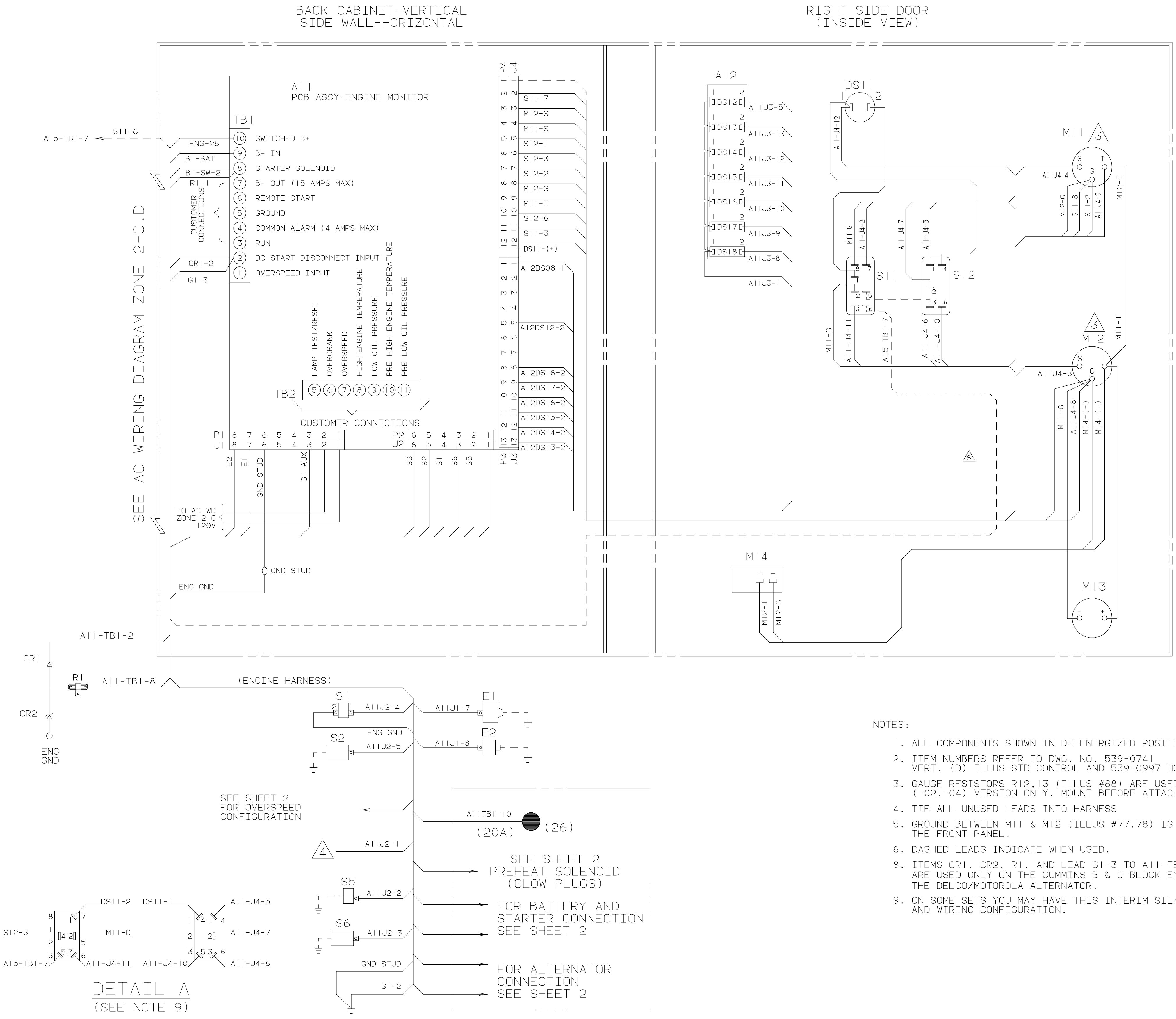
THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



No. 612–6688 sh 2of 2
Rev. N Sys: CADAM
Modified 8/3/95

12-LIGHT DC WIRING, SHEET 2 (PRIOR TO SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



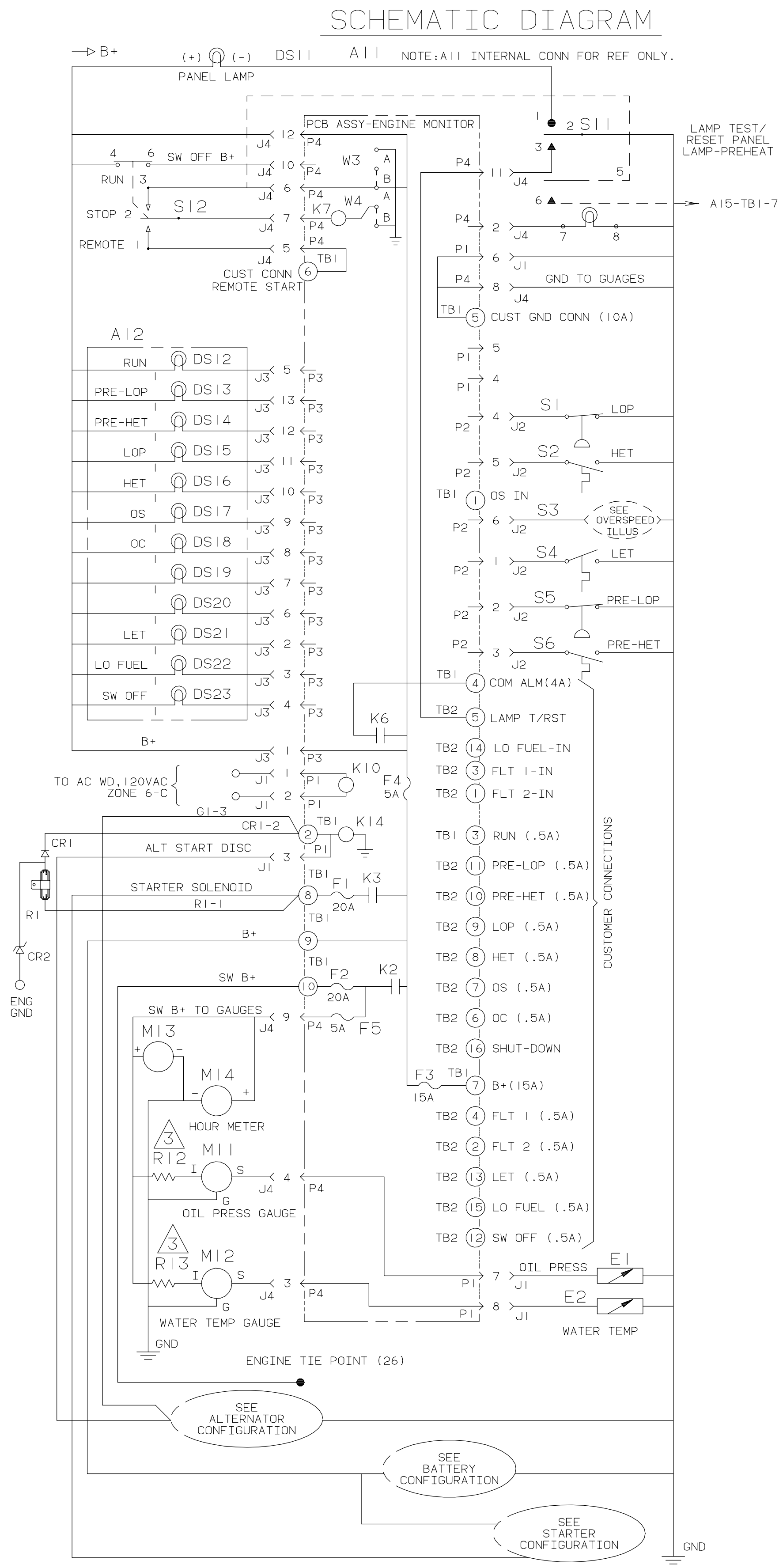
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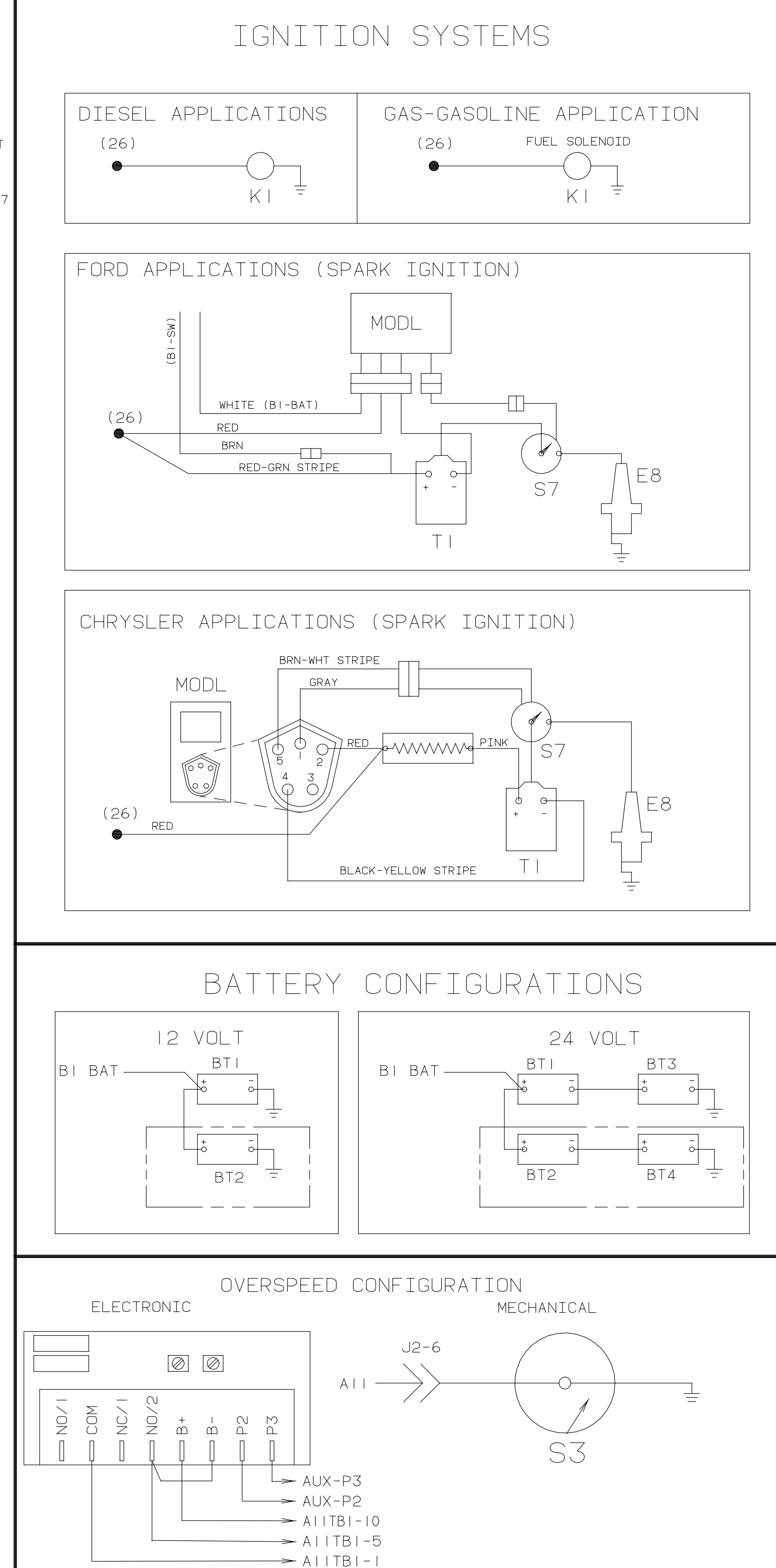
1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION
2. ITEM NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 HORIZ.
3. GAUGE RESISTORS R12,13 (ILLUS #88) ARE USED ON 24V (-02,-04) VERSION ONLY. MOUNT BEFORE ATTACHING HARNESS.
4. TIE ALL UNUSED LEADS INTO HARNESS
5. GROUND BETWEEN M11 & M12 (ILLUS #77,78) IS THROUGH THE FRONT PANEL.
6. DASHED LEADS INDICATE WHEN USED.
8. ITEMS CR1, CR2, R1, AND LEAD G1-3 TO A11-TB1-2 ARE USED ONLY ON THE CUMMINS B & C BLOCK ENGINES USING THE DELCO/MOTOROLA ALTERNATOR.
9. ON SOME SETS YOU MAY HAVE THIS INTERIM SILKSCREEN AND WIRING CONFIGURATION.

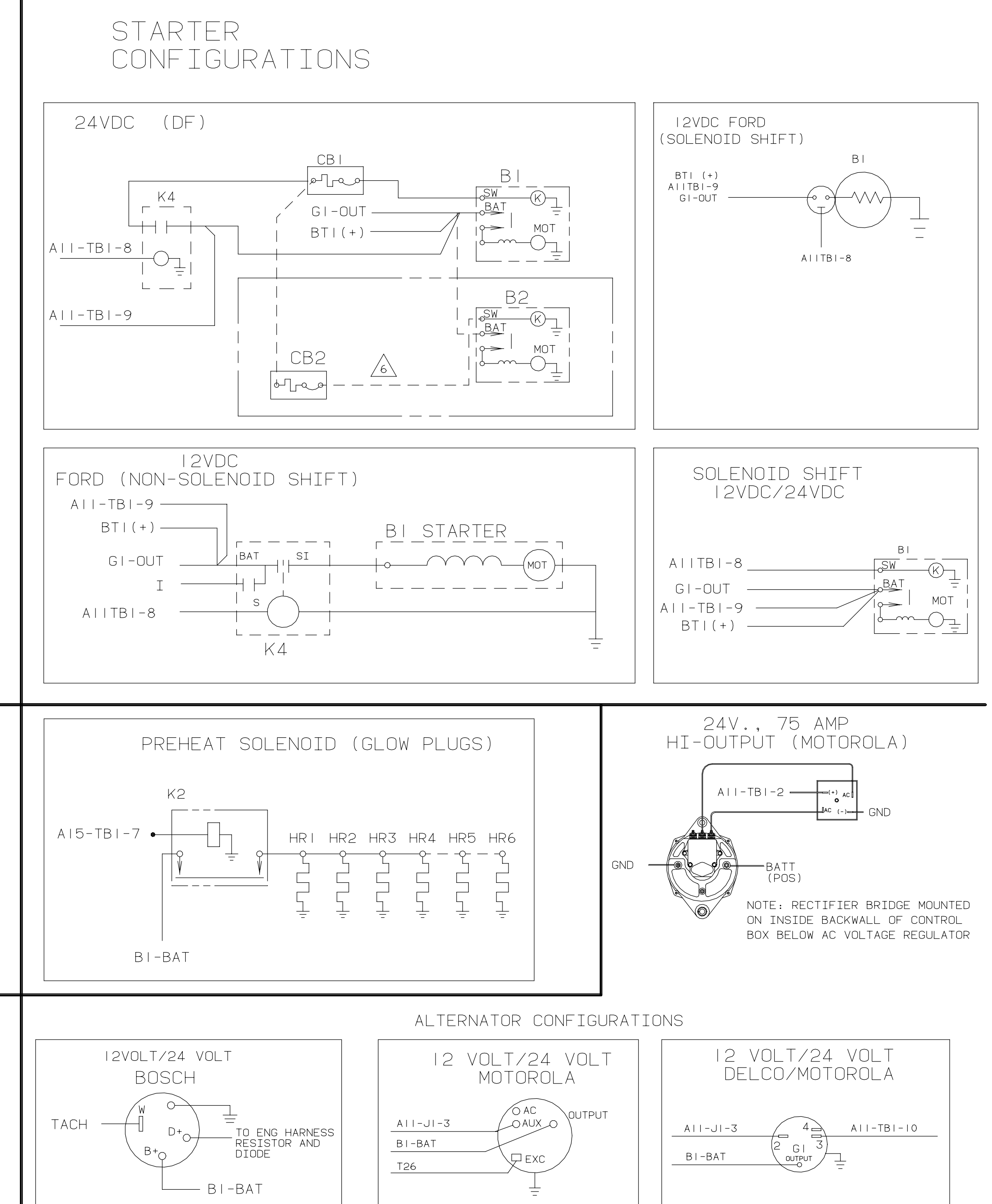
No. 612–6686 sh 1of 2
Rev. A Sys: CADAM
Modified 8/7/95

7-LIGHT DC WIRING, SHEET 1 (BEGIN SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



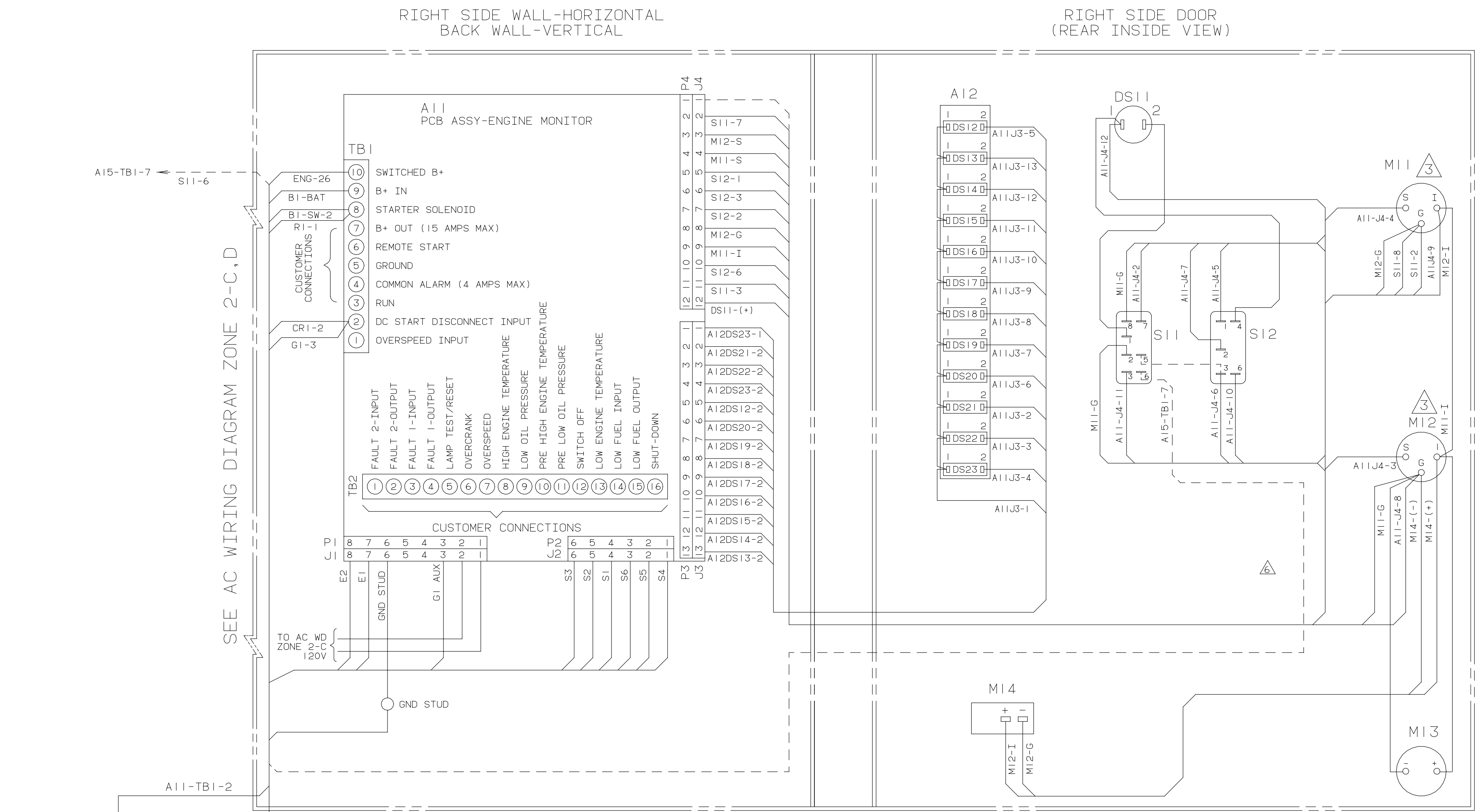


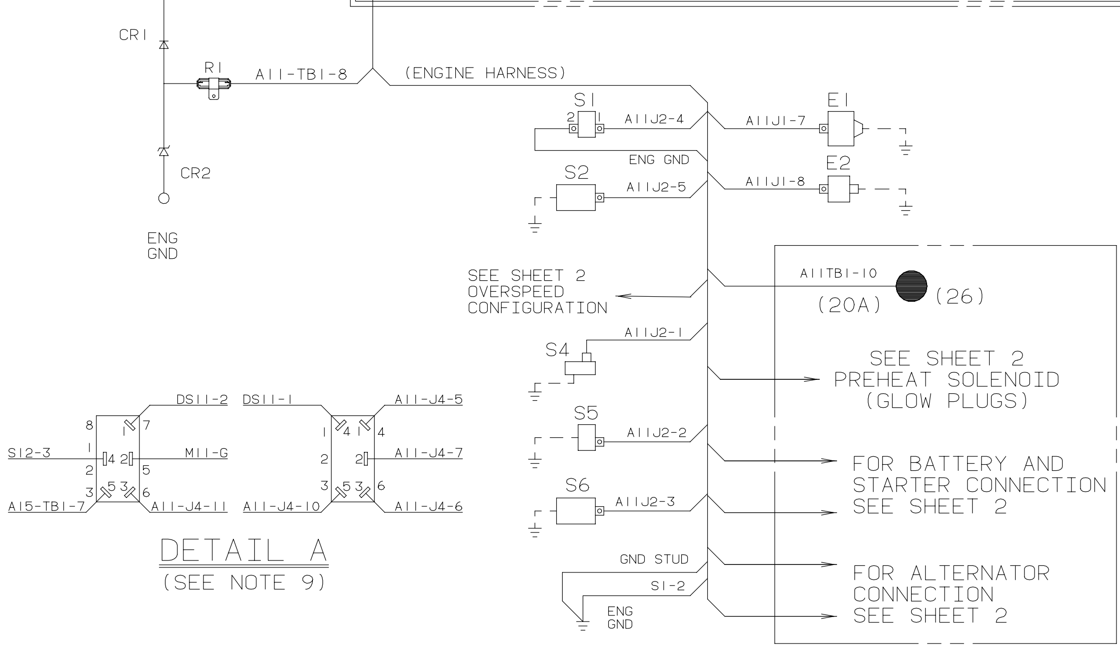


No. 612–6686 sh 2 of 2
Rev. A Sys: CADAM
Modified 8/7/95

7-LIGHT DC WIRING, SHEET 2 (BEGIN SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.





TABULATION		
DASH NO.	CONTROL	BAT. VOLTS
-01	VERT.	12V
-02	VERT.	24V

REF DES	DESCRIPTION
S6	THERMOSTAT (PRE-HET)
S5	SWITCH-PRESS (PRE-LOP)
S4	SWITCH LOW ENGINE TEMP
S3	SWITCH-OVERSPEED
S2	THERMOSTAT (HET)
S1	SWITCH-OIL PRESS (LOP)
K4	STARTER PILOT SOLENOID
K2	PREHEAT SOLENOID (GLOW PLUGS)
K1	FUEL SOLENOID
G1	ALTERNATOR
E2	SENDER-WATER TEMP
E1	SENDER-OIL PRESSURE
BT1	BATTERY-STORAGE
B1	STARTER & SOLENOID

ENGINE PARTS LIST ABOVE (SHOWN FOR REFERENCE ONLY)

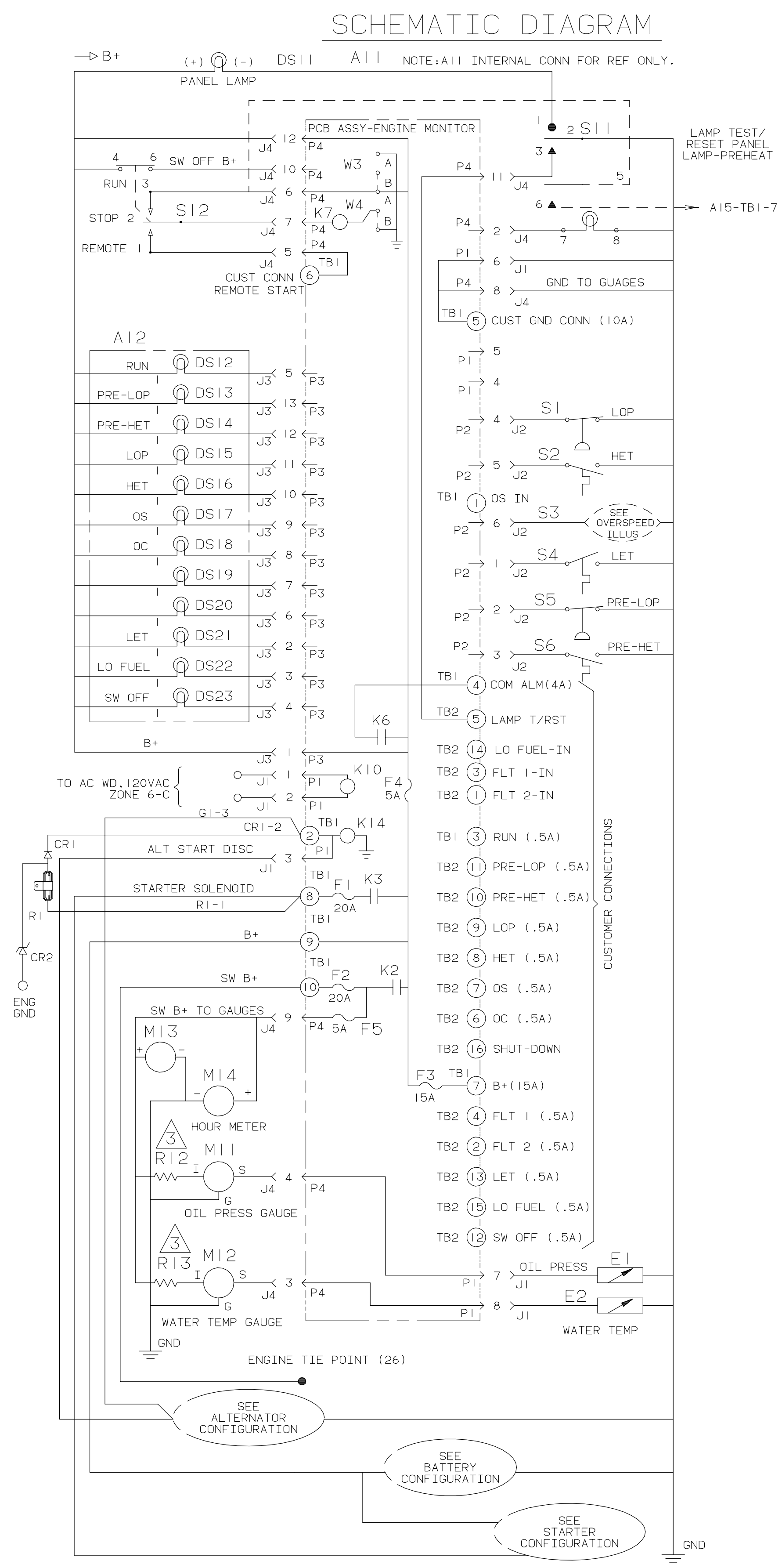
NOTES:

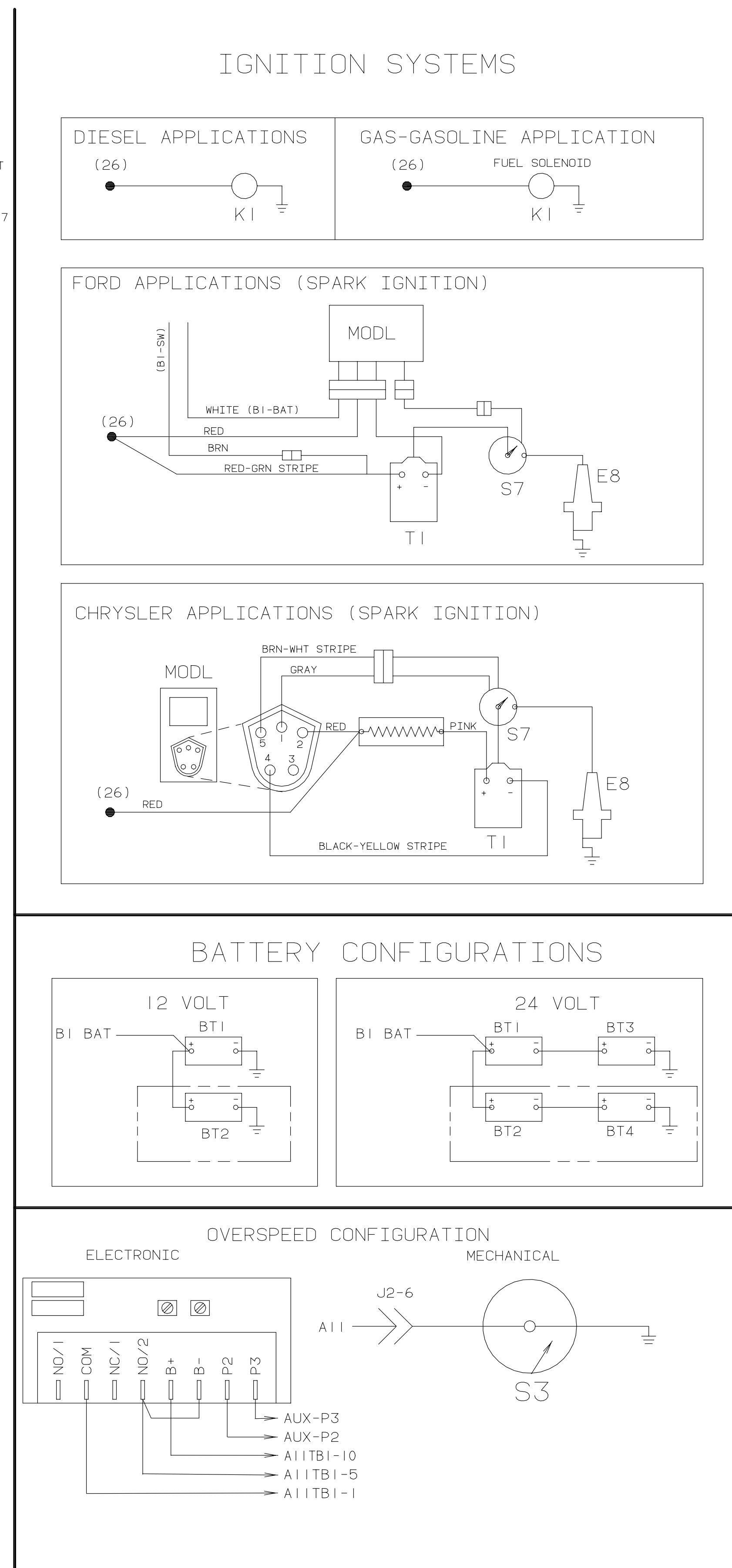
1. ALL COMPONENTS SHOWN IN DE-ENERGIZED POSITION.
2. ITEM NUMBERS REFER TO DWG. NO. 539-0741 VERT. (D) ILLUS-STD CONTROL AND 539-0997 HORIZ.
3. GAUGE RESISTORS R12,13 (ILLUS #88) ARE USED ON 24V (-02,-04) VERSION ONLY. MOUNT BEFORE ATTACHING HARNESS.
4. TIE ALL UNUSED LEADS INTO HARNESS
5. GROUND BETWEEN M11 & M12 (ILLUS #77,78) IS THROUGH THE FRONT PANEL.
6. DASHED LEADS INDICATE WHEN USED.
7. ITEMS CR1, CR2, R1, AND LEAD G1-3 TO A11-TB1-2 ARE USED ONLY ON THE CUMMINS B & C BLOCK ENGINES USING THE DELCO/MOTOROLA ALTERNATOR
8. ON SOME SETS YOU MAY HAVE THIS INTERIM SILKSCREEN AND WIRING CONFIGURATION.

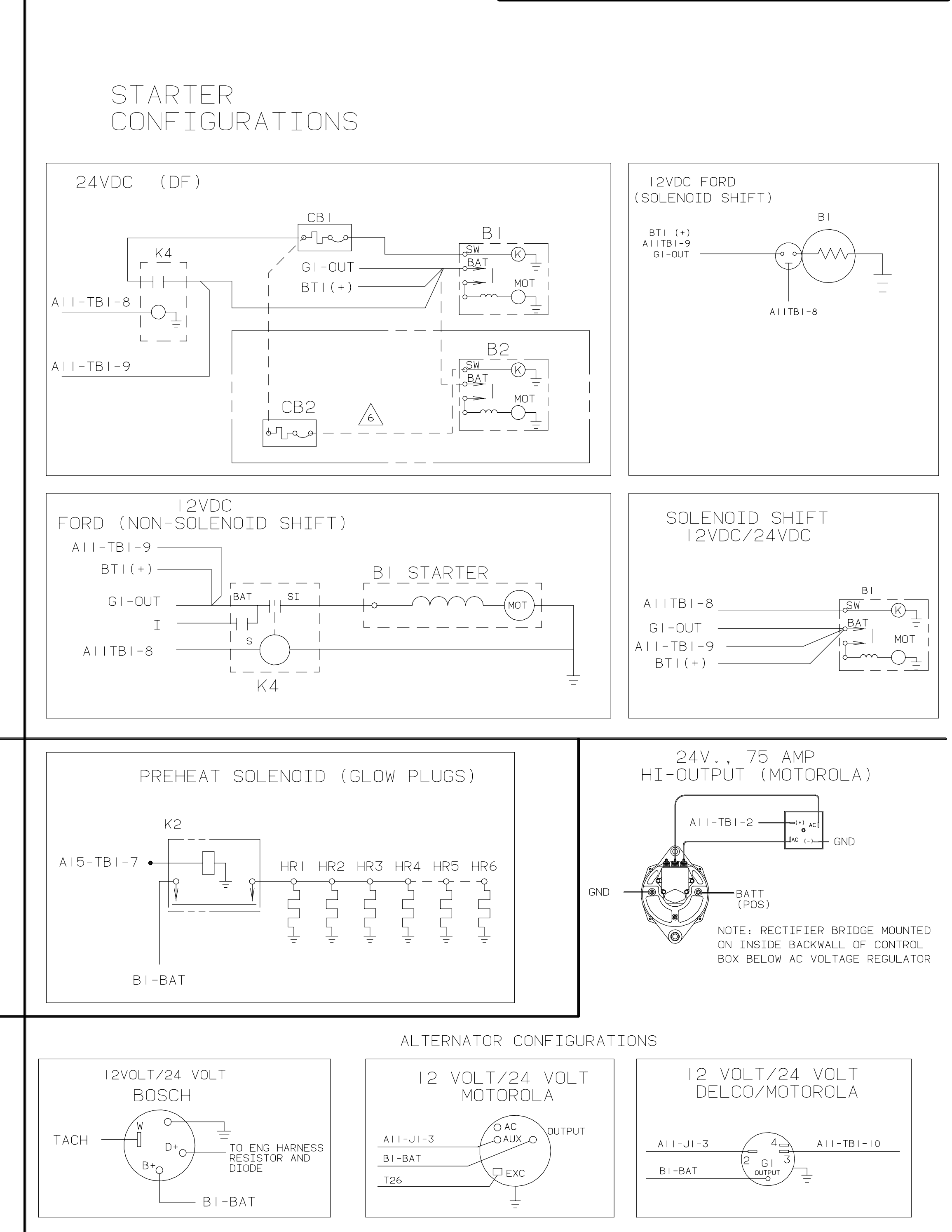
No. 612–6687 sh 1 of 2
Rev. A Sys: CADAM
Modified 8/7/95

12-LIGHT DC WIRING, SHEET 1, (BEGIN SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.





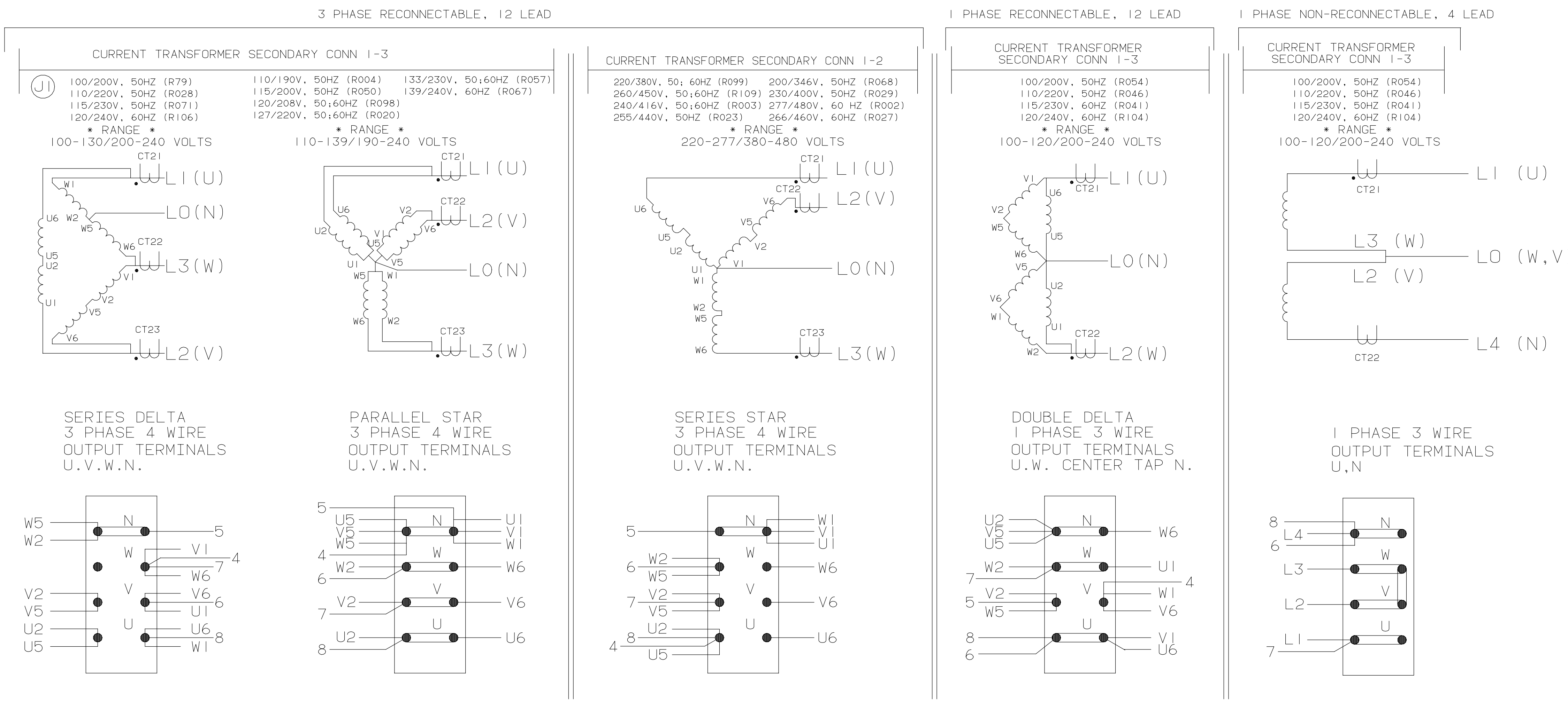


No. 612−6687 sh 2 of 2
Rev. A Sys: CADAM
Modified 8/7/95

12-LIGHT DC WIRING, SHEET 2 (BEGIN SPEC F)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

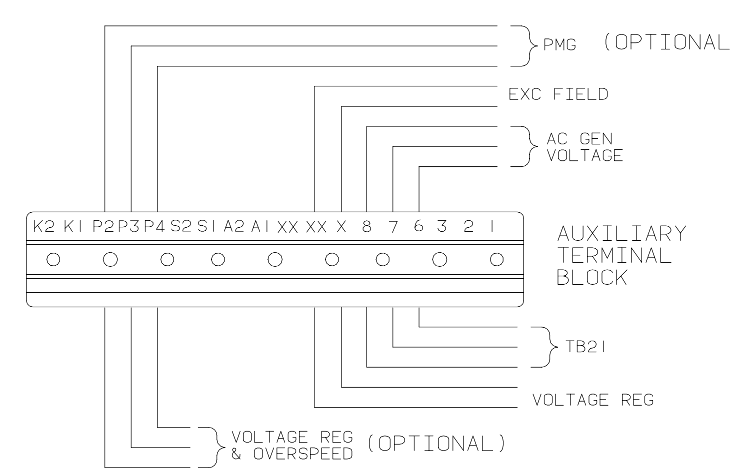
UC GENERATORS



NOTES:

1. UVW PHASE SEQUENCE WITH C.W. ROTATION FACING DRIVE END.
2. 347/600 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT GENERATOR TAP STATOR LEADS 7 & 8 TO VR21-P2 & VR21-P3 REPECTIVELY. INSULATE AND TIE #6 LEAD BACK.
3. 347/600 VOLTS - IF VOLTAGE REGULATOR ONAN P/N 300-3606 INSULATE AND TIE BACK GENERATOR TAP STATOR LEADS 6,7 & 8.
4. 240/480 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT LEAD FROM W1 (U) AND W2 (N) TO VR21-P2 AND VR21-P3 RESPECTIVELY.

CONTROL INPUT				
CONTROL INPUT TB21	SERIES DELTA	PARALLEL STAR	SERIES STAR	DOUBLE DELTA
22	8	8	8	8
23	7	7	7	7
24	4	4	4	4
25	6	6	6	6
26	5	5	5	5
JUMPER	—	—	—	—

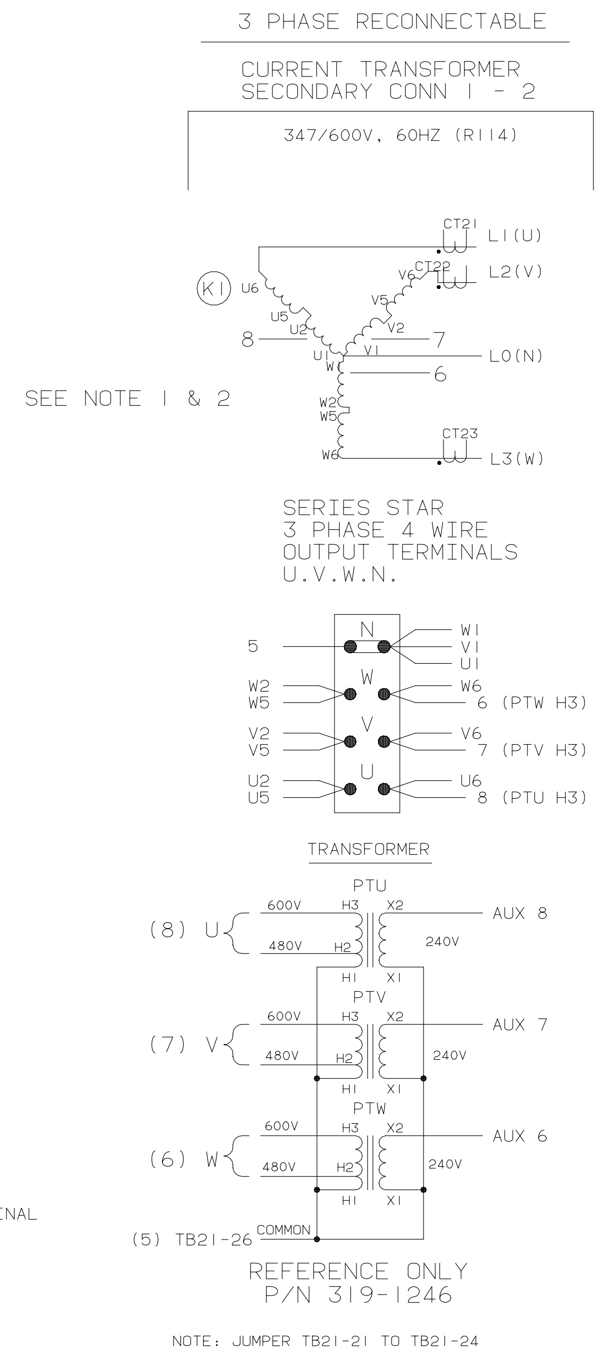


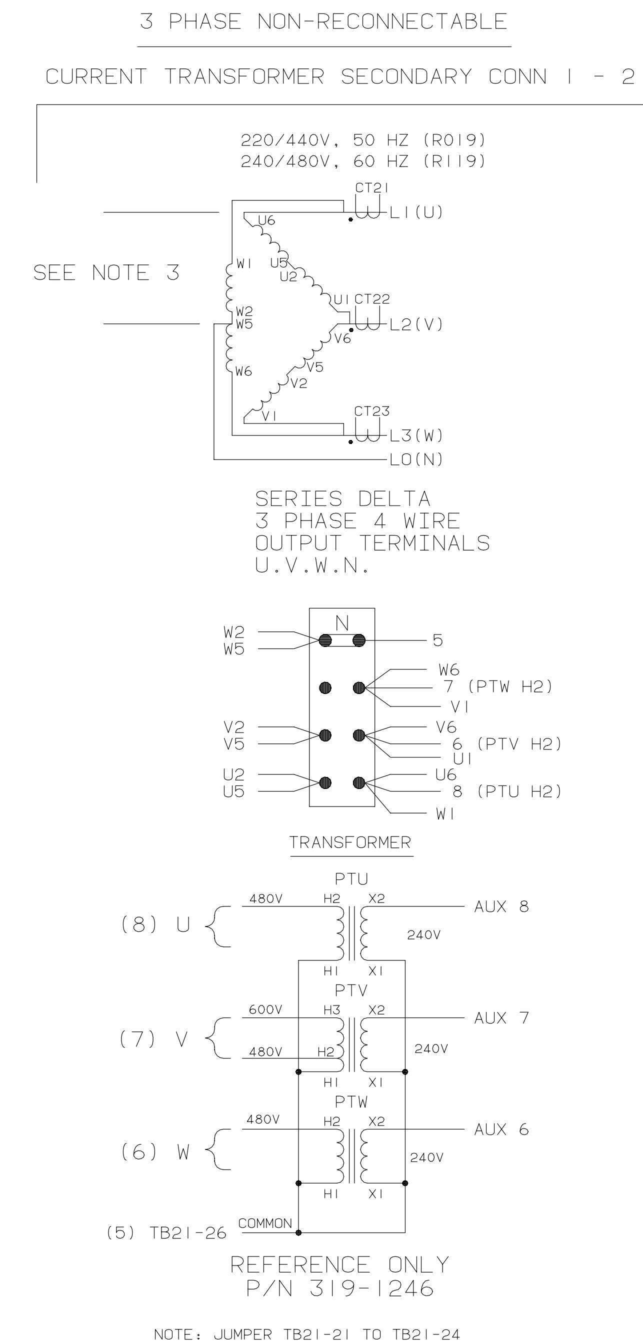
No. 625−2164 sh 1of 2
Rev. K Sys: CADAM
Modified 8/3/95

GENERATOR RECONNECTION DIAGRAM, SHEET 1 (PRIOR TO SPEC E)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

UC GENERATORS





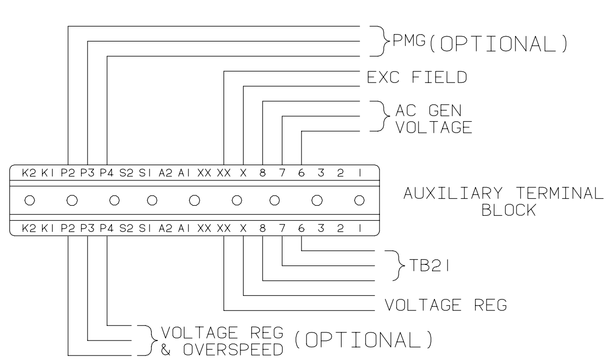
NOTES:

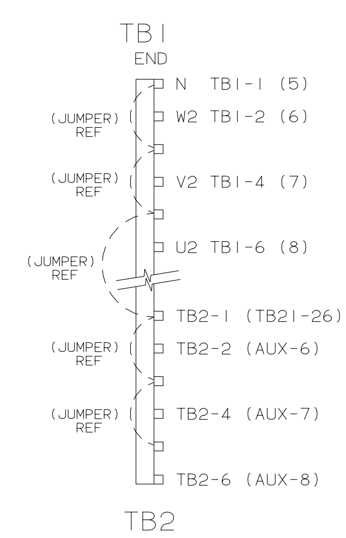
1. 347/600 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT GENERATOR TAP STATOR LEADS 7 & 8 TO VR21-P2 & VR21-P3 REPECTIVELY. INSULATE AND TIE #6 LEAD BACK.

2. 347/600 VOLTS - IF VOLTAGE REGULATOR ONAN P/N 300-3606 INSULATE AND TIE BACK GENERATOR TAP STATOR LEADS 6,7 & 8.

3. 240/480 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT LEAD FROM W1 (U) AND W2 (N) TO VR21-P2 AND VR21-P3 RESPECTIVELY.

CONTROL INPUT			
6 OR 12 LEAD			
CONTROL INPUT TB21	AUX TERM CON	SERIES STAR 347/600V	SERIES DELTA 240/480V
22	8	8	8
23	7	7	7
24	–	–	–
25	6	6	6
26	–	5	5
JUMPER	–	21 - 24	21 - 24





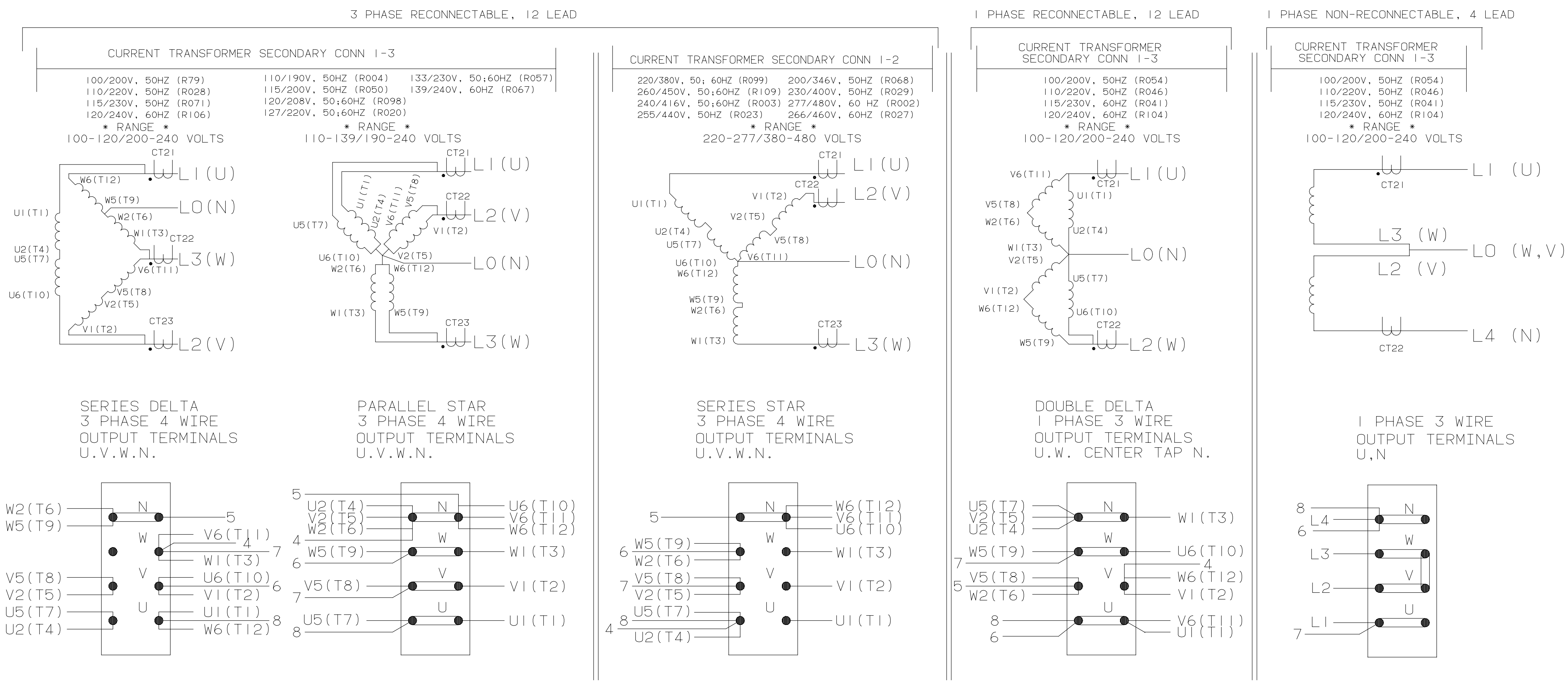
TRANSFORMER CONNECTIONS ASSEMBLY

No. 625−2164 sh 2of 2
Rev. K Sys: CADAM
Modified 8/3/95

GENERATOR RECONNECTION DIAGRAM, SHEET 2 (PROIR TO SPEC E)

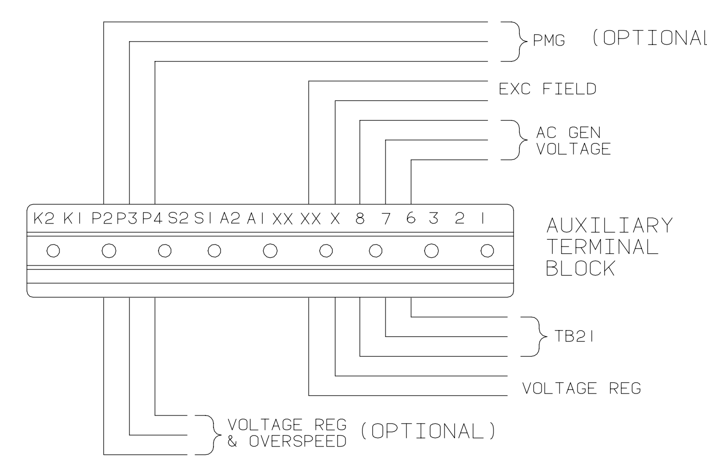
THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

UC GENERATORS



NOTES:

1. UVW PHASE SEQUENCE WITH C.W. ROTATION FACING DRIVE END.
2. 347/600 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT GENERATOR TAP STATOR LEADS 7 & 8 TO VR21-P2 & VR21-P3 REPECTIVELY. INSULATE AND TIE #6 LEAD BACK.
3. 347/600 VOLTS - IF VOLTAGE REGULATOR ONAN P/N 300-3606 INSULATE AND TIE BACK GENERATOR TAP STATOR LEADS 6,7 & 8.
4. 240/480 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT LEAD FROM W6 (U) AND W5 (N) TO VR21-P2 AND VR21-P3 RESPECTIVELY.



DETECTOR CONTROL

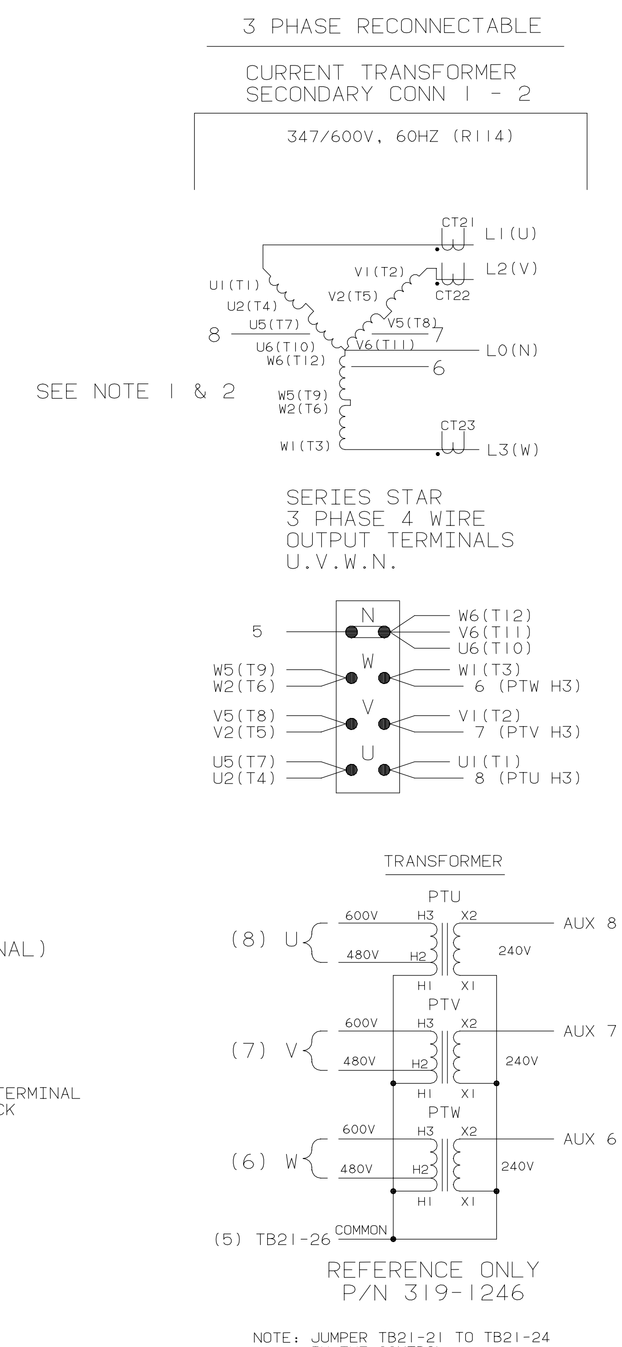
CONTROL INPUT				
CONTROL INPUT TB21	SERIES DELTA	PARALLEL STAR	SERIES STAR	DOUBLE DELTA
22	8	8	8	8
23	7	7	7	7
24	4	4	4	4
25	6	6	6	6
26	5	5	5	5
JUMPER	—	—	—	—

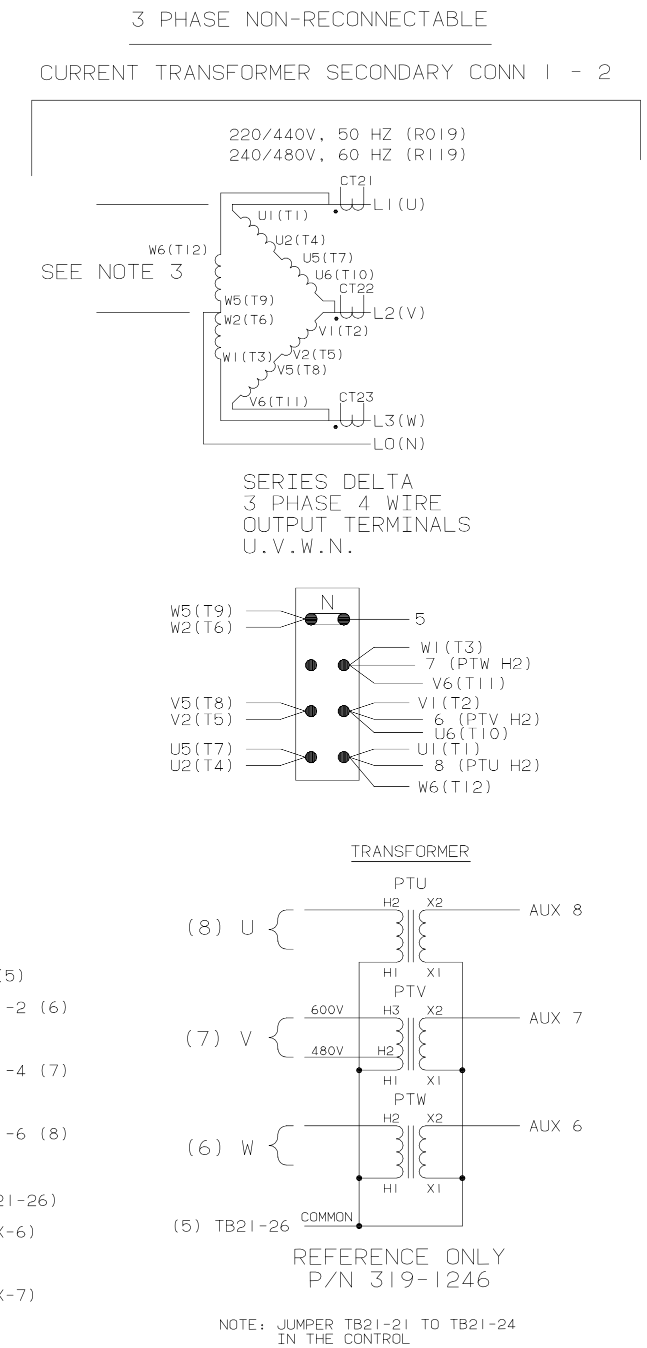
No. 625−3061 sh 1 of 2
Rev. A Sys: CADAM
Modified 8/3/95

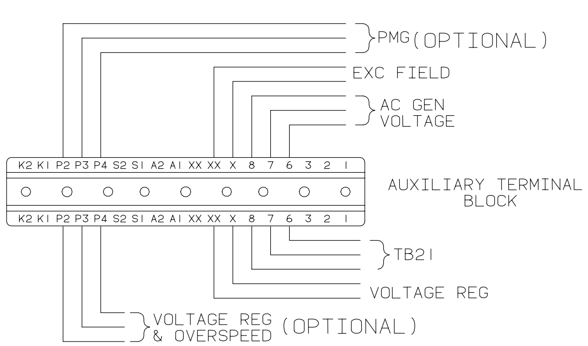
GENERATOR RECONNECTION DIAGRAM, SHEET 1 (BEGIN SPEC E)

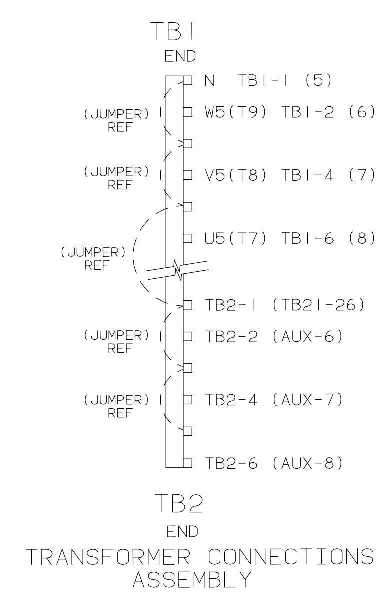
THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

UC GENERATORS









CONTROL INPUT			
6 OR 12 LEAD			
CONTROL INPUT TB21	AUX TERM CON	SERIES STAR 347/600V	SERIES DELTA 240/480V
22	8	8	8
23	7	7	7
24	–	–	–
25	6	6	6
26	–	5	5
JUMPER	–	21 - 24	21 - 24

NOTES:

1. 347/600 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT GENERATOR TAP STATOR LEADS 7 & 8 TO VR21-P2 & VR21-P3 REPECTIVELY. INSULATE AND TIE #6 LEAD BACK.
2. 347/600 VOLTS - IF VOLTAGE REGULATOR ONAN P/N 300-3606 INSULATE AND TIE BACK GENERATOR TAP STATOR LEADS 6,7 & 8.
3. 240/480 VOLTS - IF VOLTAGE REGULATOR SX440 ONAN P/N 300-3607 IS SPECIFIED, CONNECT LEAD FROM W6 (U) AND W5 (N) TO VR21-P2 AND VR21-P3 RESPECTIVELY.

DETECTOR CONTROL

No. 625−3016 sh 2 of 2
Rev. A Sys: CADAM
Modified 8/3/95

GENERATOR RECONNECTION DIAGRAM, SHEET 2 (BEGIN SPEC E)

TB1-10 (SWITCHED B+ OUTPUT) OUTPUT TO RELAY K12, FUSED AT 20 AMPS, ENERGIZED WHEN THE START SIGNAL IS APPLIED AND DE-ENERGIZED AT SHUTDOWN (NORMAL AND FAULT)

TB1-9 (B+ INPUT) BATTERY POSITIVE (+) CONNECTION

TB1-8 (START SOLENOID) OUTPUT TO RELAY K11, FUSED AT 20 AMPS

TB1-7 (B+ OUTPUT) OUTPUT TO TIME DELAY START/STOP MODULE A15, FUSED AT 15 AMPS, AVAILABLE WHEN THE STARTING BATTERIES ARE CONNECTED

TB1-6 (REMOTE START) CONNECTED TO TIME DELAY START/STOP MODULE A15. CONNECT REMOTE START CONTACT OF THE AUTOMATIC TRANSFER SWITCH TO TERMINAL TB1-5 OF MODULE A15.

TB1-5 (GROUND)

TB1-4 (COMMON ALARM B+ OUTPUT) 4 AMP RATED DEVICE MAXIMUM

TB1-3 (RUN) CONNECTED TO TIME DELAY START/STOP MODULE A15

TB1-2 (DC DISCONNECT) CONNECTED TO TIME DELAY START/STOP MODULE A15

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.

TB2-1 (FAULT 2) GROUND INPUT FROM SENDER

TB2-2 (FAULT 2) GROUND OUTPUT TO LIGHT/RELAY*

TB2-3 (FAULT 1) GROUND INPUT FROM SENDER

TB2-4 (FAULT 1) GROUND OUTPUT TO LIGHT/RELAY*

TB2-5 (REMOTE RESET) MOMENTARY CONTACT TO GROUND

TB2-6 (OVERCRANK FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-7 (OVERSPEED FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-8 (HIGH ENGINE TEMPERATURE FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-9 (LOW OIL PRESSURE FAULT) GROUND OUTPUT TO LIGHT/RELAY*

TB2-10 (PRE-HIGH ENGINE TEMPERATURE WARNING) GROUND OUTPUT TO LIGHT/RELAY*

TB2-11 (PRE-LOW OIL PRESSURE WARNING) GROUND OUTPUT TO LIGHT/RELAY*

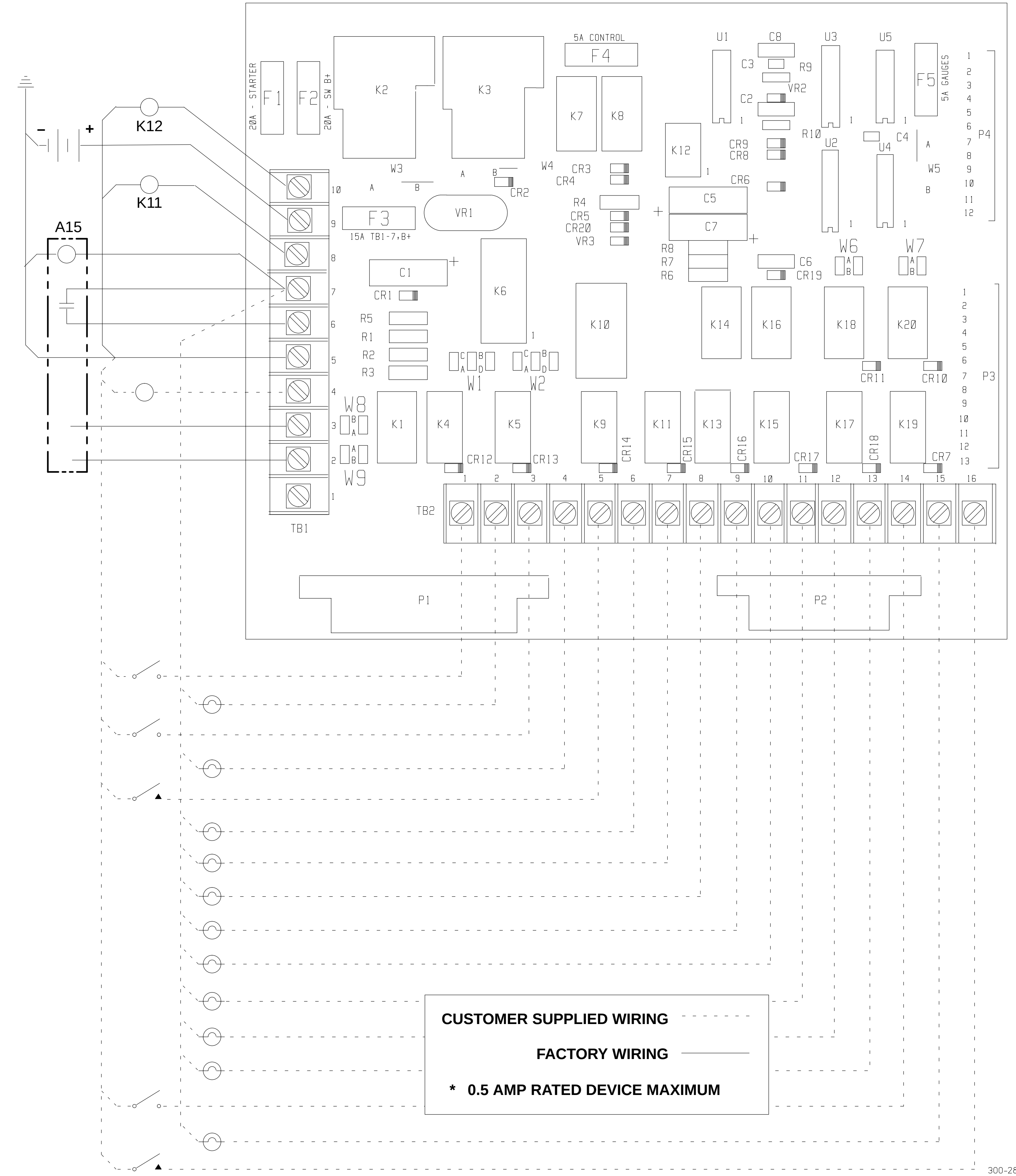
TB2-12 (SWITCH OFF WARNING) GROUND OUTPUT TO LIGHT/RELAY*

TB2-13 (LOW ENGINE TEMPERATURE WARNING) GROUND OUTPUT TO LIGHT/RELAY*

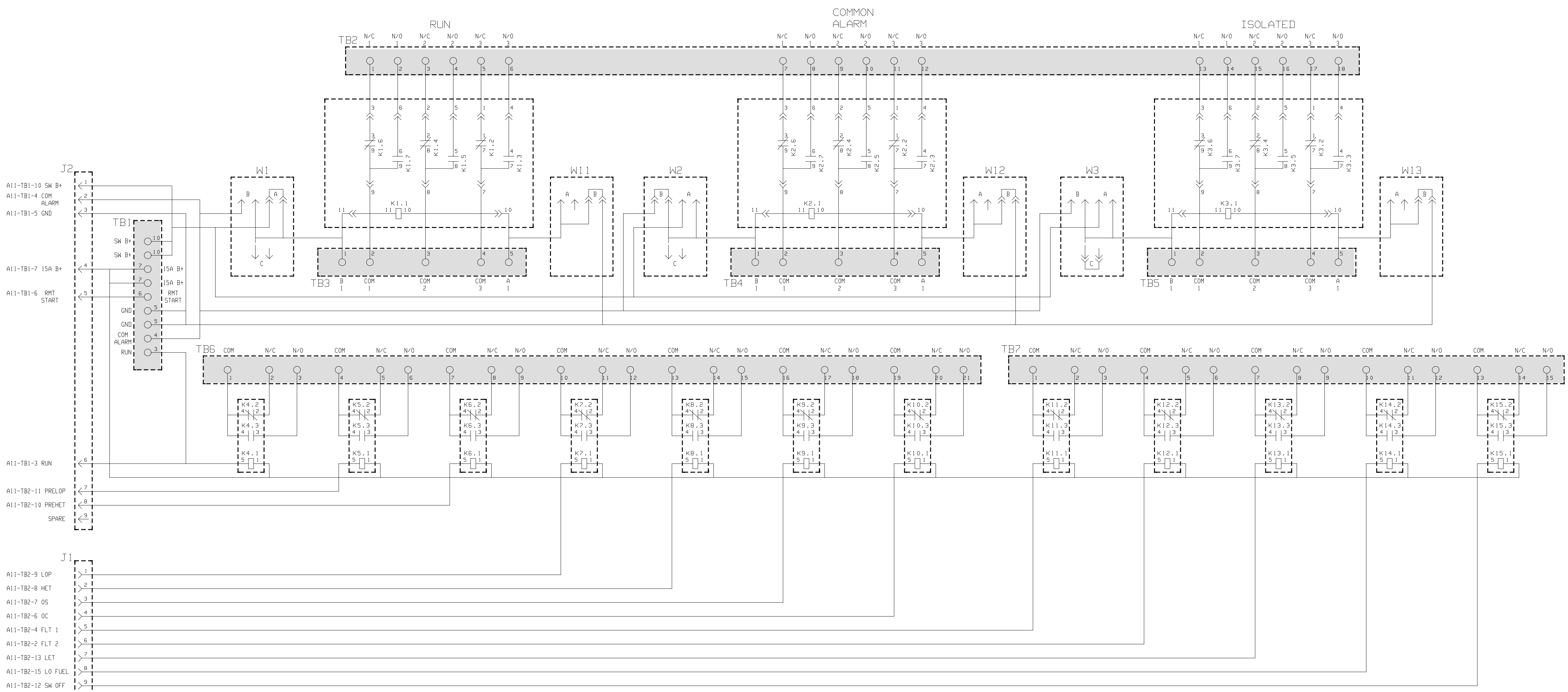
TB2-14 (LOW FUEL WARNING) GROUND INPUT FROM SENDER

TB2-15 (LOW FUEL WARNING) GROUND OUTPUT TO LIGHT/RELAY*

TB2-16 (EMERGENCY SHUT DOWN) MOMENTARY CONTACT TO GROUND



FACTORY AND CUSTOMER CONNECTIONS AT THE ENGINE MONITOR BOARD TERMINALS

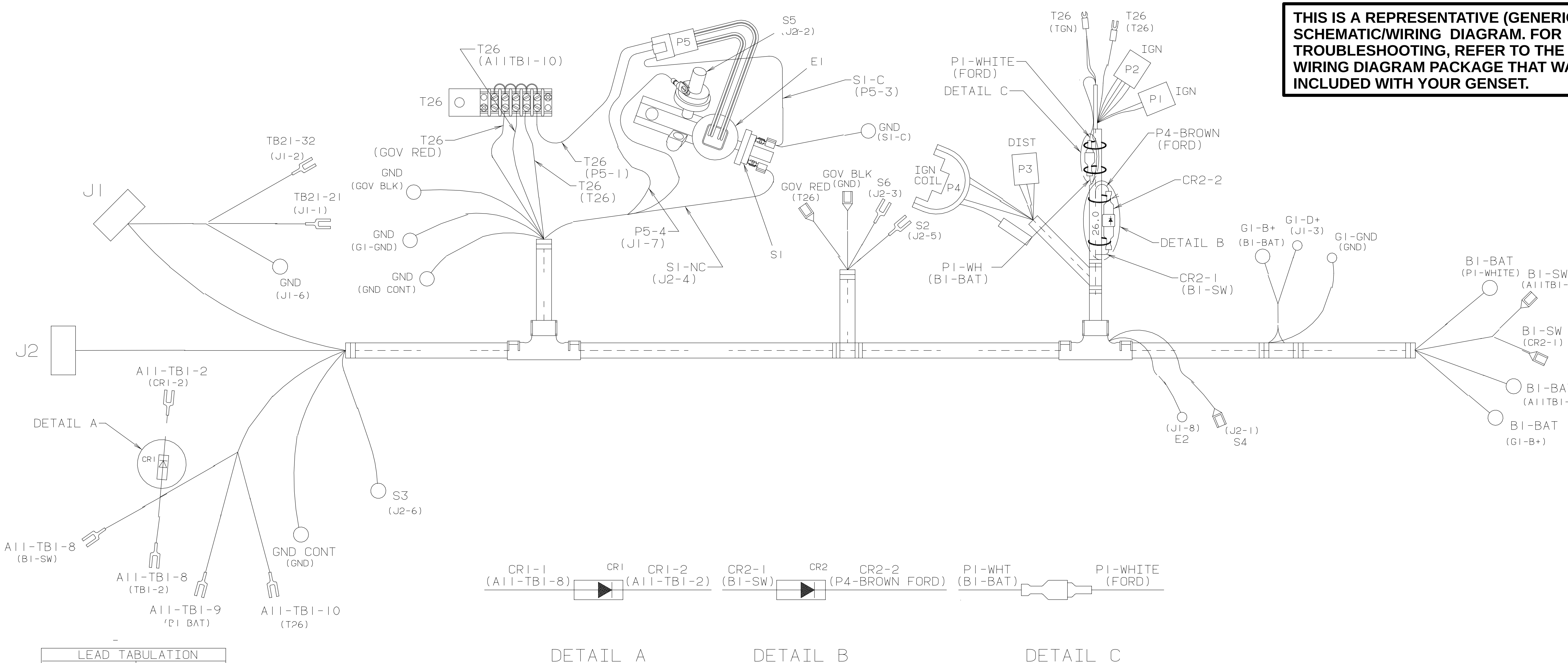


THE TERMINALS IN THE SHADED BOXES ARE FOR CUSTOMER CONNECTIONS

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CUSTOMER CONNECTIONS AT THE AUXILIARY RELAY BOARD (DETECTOR CONTROL)

THIS IS A REPRESENTATIVE (GENERIC) SCHEMATIC/WIRING DIAGRAM. FOR TROUBLESHOOTING, REFER TO THE WIRING DIAGRAM PACKAGE THAT WAS INCLUDED WITH YOUR GENSET.



LEAD TABULATION	
FROM STATION	TO STATION
S1-NC	J2-4
S2	J2-5
S3	J2-6
S4	J2-1
S5	J2-2
S6	J2-3
A11-TB1-2	CR1-2
CR1-1	A11-TB1-8
T26	A11-TB1-10
GND	G1-GND
A11-TB1-9	B1-BAT
GND	GND-CONT
P5-4	J1-7
E2	J1-8
G1-D+	J1-3
G1-B+	B1-BAT
B1-BAT	P1-WHITE
B1-SW	CR2-1
B1-SW	A11-TB1-8
J1-1	TB21-21
J1-2	TB21-32
J1-6	GND-CONT
T26	T26
T26	GOV RED
GND	GOV BLK
GND	S1-C
P5-1	T26
P5-3	S1-C

No. 338−3308 sh 1of 1
Rev. A Sys: CADAM
Modified 7/24/95

ENGINE HARNESS (BEGIN SPEC F)

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